

What is the Future British Population?

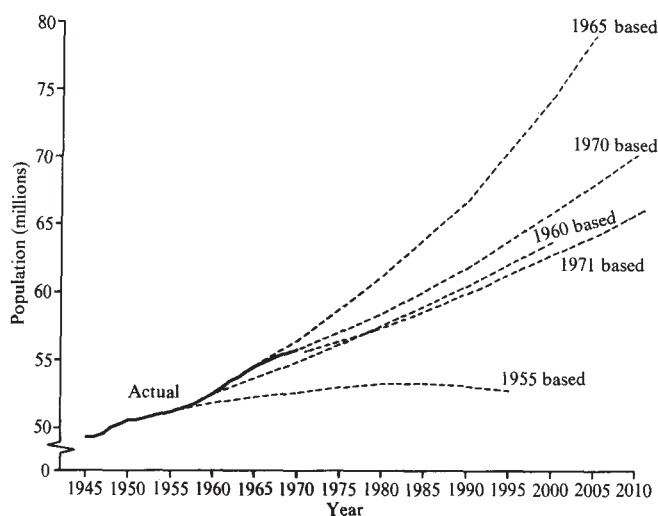
WITH all the current excitement about the growth of population in the world, it is inevitable that great interest will attach to the second report of the Government Actuary giving population projections between 1971 and 2011 (HMSO, £1.00). The best news is that the Government Actuary now proposes to publish population projections once a year. The second cause for cheerfulness is that the projections now published are substantially less than those put out only a year ago. For the United Kingdom as a whole, the population in 2001 is now projected at 63.1 million, five per cent below the projection of a year ago. The projected increase of population between now and the end of the century is 7.4 million compared with the projected increase of 10.5 million a year ago. On the face of things, at least, the population projections seem to be moving in the right direction.

This is why it is important that too much should not be made of the projections now available. Predicting the growth of a population is a most hazardous exercise. One of the reasons for the difference between the projections made in 1971 and 1972 is that last year's census revealed that the population of the United Kingdom is 400,000 less than had been suggested by the accumulation of birth and death certificates since the previous census in 1961, no doubt because emigration from Britain had been under-estimated (which is why the new projections also assume that emigration in the years ahead will remove an extra 20,000 people each year from Britain). But the principal cause of the difference between the successive projections is that the experience of the past few years has compelled more modest assumptions about fertility. The hazard here for the demographers is that the observed reduction of fertility among married women may be a result of the postponement of child-bearing, not a sign that completed family size will eventually be correspondingly reduced. This is why the Government Actuary has made only a cautious revision of the estimates of average family size since the last set of projec-

tions—it is now assumed that women married or marrying in 1967 or later will on the average have 2.33 children, not 2.40 as was supposed a year ago.

It is plain that nobody should be surprised if future annual projections of the British population turn out to differ markedly from those now published. If the recent decline of fertility continues, or if events show that it leads to a completed family size significantly less than that on which the latest projections are based, the result could be a still further reduction of the projected population by the end of the century. It is by no means beyond the bounds of possibility that the increase of the British population in the next decade will turn out to be even less than the 3.6 per cent now projected. On the other hand, as the experience of the post-war decades has shown vividly enough, there is no assurance that fertility will not in future increase to the levels which obtained in the early 1960s. And now there is a new imponderable—how will British membership of the European Community affect international migration? There is at least a chance that the outward flow from Britain will be accelerated by the demands for labour in countries such as West Germany. It follows that regular readers of the Government Actuary's report should be prepared to be surprised.

What does the latest set of projections imply for that nebulous concept—a population policy? According to the projections now published, the number of children in the United Kingdom under the age of 15 will have decreased between 1971 and 1981, from 13.5 million to 13.4 million. In the same period, the number of adults of working age will have increased from 33.27 million to 34.6 million, while the number of those above retirement age will have increased proportionately still more rapidly, from 8.9 million to 9.7 million. On the present projections, the numbers of children in the population will begin to increase substantially only in the late 1980s, as the children born in the 1960s reach child-bearing age (and this is the part of the projection most likely to be falsified if recent fertility trends continue). It follows that for the next decade at least, the most burdensome demographic trend will be the increase of about 12 per cent in the numbers of people in retirement, but the growth of the working population should in strictly economic terms be partially a recompense. It follows that those who would seek to stabilize the British population would be well advised to concentrate their attention on the young people still at school who are the potential parents of the 1980s. Is it beyond the wit of what is after all a sophisticated educational system to devise educationally acceptable courses of instruction that will bring home to young people the importance to them as individuals, and not merely the convenience to the nation as a whole, of trying to ensure that the number of children at school in the 1980s is not very different from what it is at present? But then, again as a matter of personal liberty, there is a case for a still more urgent development of family planning services, abortion on demand included.



UK Population Projections 1955-71.



Paper Policy

WHEN is a policy not a policy but a pretence? On the face of things the ministerial meeting on European space research (see *Nature*, 240, 61; 1972) seems chiefly to have persuaded the representatives of European governments at present involved with ESRO and ELDO that the time has come to devise a new umbrella beneath which European space research can shelter. By all accounts, the British government is now one of the principal advocates of a European agency through which national expenditures on space research would in future be channelled. The principle is, of course, entirely laudable. The difficulty is that there is as yet no agreement among European nations on the kinds of work that should be attempted. The French government is now more isolated than ever in its belief that an independent European launching system is essential and, to tell from what Mr Michael Debré, the French Minister of Defence, has been saying in Paris in the past few days, it is unlikely to change its mind. But there are also profound differences of emphasis in the ambitions of other European governments, and Belgium has become conspicuous for its unwillingness to contribute to projects that do not yield a quick return. And, hanging over everything, there is the question of whether European governments, separately or collectively, should play some part in the post-Apollo programme of the United States.

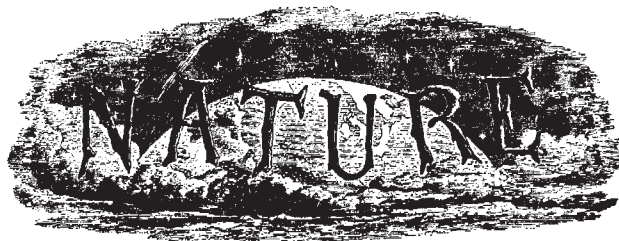
In the circumstances, it is easy to see why Mr Michael Heseltine, Minister for Aerospace, has been tempted to advocate a scheme which would have the effect of concealing the differences between European nations on what should be attempted. His concept of a European space agency is said to be one responsible for the administration of projects as different as the design of particular satellites for scientific research and the development of the Europa launching rockets on which the French are keen. Individual governments would be required to contribute only to those projects in which they had an interest. Although this device would have the advantage of making some continuing use of the facilities with which ESRO and ELDO have been provided in the past few years, and although there would no doubt be some economies of scale, there is nothing in what is now proposed to avoid the troubles that have plagued ESRO and ELDO, especially the tensions that arise when one member declines to contribute to a project on which others are keen.

This is why it would be better for the long-term health of space research in Europe if arrangements could be made for the space agency to operate, from the beginning, as a strictly common channel for funds and a means of executing work. The ideal is that the member nations should identify those areas of work they all consider to be desirable, and that they should then agree that the managers of the agency should be allowed to spend the funds available as they think fit, and without artificial restrictions such as the need to return contributions to the contributing states in the form of contracts let. It is true that such an arrangement would not be all-embracing, but there is no reason why governments wishing to sponsor extra work should not do so on their own, if necessary making separate arrangements with the space agency for services provided. The over-

riding difficulty, from which the governments seem now about to shrink, is that a space agency run on lines like this could be created only after there was a common view on what would constitute a common research policy.

But why not grasp that nettle? Most European governments agree that they must support the development of scientific satellites such as the ESRO-4 satellite due to be launched from the United States this month. There is also common agreement that the technology of communications satellites should be pursued, if on a modest scale. Taken together, these activities are enough to give a European space agency a useful job to do. At the beginning at least, there would be no need to make the agency's existence a reason for prohibiting bilateral agreements between member nations and the United States and the Soviet Union for particular extra projects, but in due course the agency could well become the agreed channel for all activities like these. On balance, there is a case for thinking that participation in the post-Apollo programme should be excluded from the agency's work, if only because European governments appear to be hopelessly divided about the desirability of such a scheme. At this stage, it is better to aim at arrangements which are wholeheartedly collaborative and not illusions of collaboration.

100 Years Ago



Misleading Cyclopædias

CAN any of your readers inform me if there is such a thing as a good and honestly constructed cyclopædia—one that does not send you hunting for information from one volume to another, and refer you backwards and forwards to articles that do not exist?

I have been repeatedly annoyed by this kind of will-o'-the-wisp, but have to-day met with such an outrageous example of it, that, although it involves some trouble, I feel it to be a duty to make a public exposure of it in your columns.

Requiring some facts on unusual atmospheric refraction, I turned to "Refraction" in the "English Encyclopædia." This article referred me to "Mirage, Fata Morgana," &c., for information on this branch of the subject. Turning to "Mirage," I found not a word, but another reference to "Reflection and Refraction, Atmospheric, Extraordinary." Next I tried "Fata Morgana," again the same reference. Coming back to letter R, I found the article "Reflection and Refraction," but was here referred to "Light, Optics, Refraction, Refrangibility;" then to letter A, "Atmosphere, Atmospheric"—nothing on the subject. Letter E, "Extraordinary Refraction"—nothing but a reference back again to "Mirage!" "Light, Optics, and Refrangibility" contain nothing on the subject.

I was thus sent on a search through five volumes of the work, and made to hunt out nine distinct headings for what does not exist; and what makes the matter worse is, that the writer of the article "Refraction," at the end of the work, must have known that it did not exist when he referred back to "Mirage, Fata Morgana," &c., which words have not a word of information appended to them.

An alphabetical cyclopædia is so much the most convenient for reference, and might be such an invaluable addition to a library, that it is the more to be regretted that it should be brought into disrepute by the absence of all efficient editorial supervision.

A. R. WALLACE

From *Nature*, 7, 68, November 28, 1872.

OLD WORLD

THE numbers of graduates who obtained their first degree in 1971 and who were still unemployed at the end of that year increased by 2.4 per cent last year to reach the highest level for many years—7.9 per cent. The hardest hit were applied science graduates, of whom 6.7 per cent were still without work at the end of 1971, compared with 2.9 per cent a year earlier.

The figures, published this week by the University Grants Committee (*First Employment of Graduates*, HMSO, £0.75), confirm the gloomy predictions made last year by university appointments officers. The rise in the total number of unemployed graduates continues the trend started in 1965 when only 2.3 per cent of new graduates were unemployed at the year's end, but it is the largest leap in a single year. The numbers of new graduates whose destinations were unknown at the end of last year also reached a new peak of 10.1 per cent, an increase of 1.6 per cent.

But 1971 may prove to have been the trough for graduate employment. Predictions that 1972 was going to be even worse are now being withdrawn by university appointments officers who are saying that the situation may have improved slightly over 1971, although final figures will not be available until next year.

And 1973 may even be better. The Central Services Unit for the appointments boards—established in August at Manchester—reports that there are definitely more jobs for the 1973 output than there were at this time last year for the 1972 graduates. Appointments officers report that graduates, having seen the increasing difficulties encountered by those finishing last year and the year before, are willing to look much more widely for work; scientists particularly are coming to accept that their job may well not be related to their degree, something that arts graduates have lived with for years. Employers too are adapting, recruiting graduates into jobs previously filled by school leavers. And areas of commerce, such as insurance, accountancy and retail selling, are increasingly recruiting at the graduate level.

New pastures for graduate recruitment are to be welcomed, for the 1971 figures reveal that industry—the traditional first employer of the graduate—cut its intake of both first and second degree graduates from about 17.3 per cent of the total in 1970 to 13.3 per cent in 1971. Other employers increased their intake, however; the public sector

took 1,238 more graduates in 1971, and 550 more graduates went straight into educational jobs without further training, but overall the number entering permanent employment in Britain fell from 21,399 in 1970 to 20,820 in 1971.

The number of men going on to higher education and research in the pure sciences fell to 28.1 per cent of those graduating in 1971—lower even than the figure for 1969—and the number of women entering research in pure science also fell—from 15.3 per cent to 14.5 per cent. By contrast the number of both men and women entering research in the applied sciences rose by about 0.5 per cent—the reverse situation to 1970 when those moving on to pure

science research and further education rose, but applied science numbers fell.

The figures published this week seem to belie the often quoted argument that university courses ought to be more relevant to future employment. The University of Lancaster, one of the newer universities with courses that are claimed to be relevant to current needs, has the highest unemployment rate at 16 per cent, with a further 11 per cent "unknown", and the University of Manchester Institute of Science and Technology is easily above the national average with 9.4 per cent unemployed. (In fairness it should be pointed out that the University of Strathclyde has an unemployment rate of barely 2 per cent.)

Research Recommended

RESEARCH on superconducting a.c. generators should start as soon as possible, according to a report from the Science Research Council (*Report on Superconducting a.c. Generators*, available free from the SRC). The report states that the future of superconducting a.c. generators is far from certain—and that in any case they will not be needed before the 1990s—but that research must start now if they are to be available by then. Further, Britain is leading the field in some aspects of superconductivity, including helium refrigerators, materials, magnets and d.c. machines.

The report therefore recommends an immediate, although not large, research programme in universities, and identifies topics like the properties of helium in a rotating frame of reference, eddy-current losses and the fatigue and hysteretic heating of composite materials as suitable for the attention of university departments.

Superconducting generators produc-

ing more than 1,000 MW will offer greater efficiency for smaller size, weight and cost than conventional machines. There are, however, many technical and economic risks involved in the development programme. The working party of the Electrical and Systems Engineering Committee of the SRC, which produced the report, has outlined a likely timescale for the development of a superconducting generator, involving the successive construction of 60 MW, 600 MW and 1,000 MW sets (see table). The 60 MW prototype is expected to cost about £2 million.

The working party comes out against creating a special centre for studies of superconductivity, but it does recommend that the university work be closely linked to industrial development by the CEEB and such companies as GEC and Reyrolle Parsons (IRD), through the secondment of academics to industry and through research studentships financed by the SRC. The universities' task would be to obtain "basic data and the criteria necessary for determining design parameters" for superconducting a.c. generators.

Table 1. Likely Timescale for the Development of Superconducting Generators

Year	1973	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
Research	←				→															
Rig work and construction of 60 MW prototype				←					→											
Running of prototype								←		→										
Design and construction of 600 MW machine										←					→					
Design and construction of 1000 MW machine																←				→

The survey shows that the number of first degrees awarded in 1971 increased by 3.4 per cent to 49,197, while the number of higher degrees increased by 963, or 8.3 per cent, to 12,365. Of these higher degrees, 7,917 (64 per cent) were in science subjects, and of those 911 men continued further research in the pure sciences and 374 in applied science. The figures for women are 83 and 15 respectively. Of the 1,383 higher degree science graduates who stayed in research 306 went overseas.

MEDICINE

Contracting In

THE Department of Health and Social Security last week launched its long awaited scheme designed to increase the numbers of kidneys available for transplantation. The scheme will rely on potential donors carrying with them a card, supplied by the department, which signifies that the person is willing for his kidneys to be transplanted in the event of his death.

By selecting this method of augmenting the supply of kidneys, the department has chosen one of the less radical alternatives open to it. In 1969 an advisory group set up under Sir Hector MacLennan to consider problems of organ transplantation was divided in its recommendations but a majority urged that a contracting-out scheme be instituted by which a person would automatically be considered to have given consent for his kidneys to be removed after death unless there was evidence to the contrary. Such a scheme would almost certainly produce enough kidneys, but the department has chosen to promote a contracting in scheme whose success will depend greatly on the publicity accorded it.

There is still a large gap between the supply of kidneys for transplantation and the demand. Last year 315 kidneys were transplanted in Britain, an increase of 41 over 1970. But between 1,500 and 2,000 people between the ages of 5 and 55 die every year from kidney diseases. Most of these are teenagers. Professor R. Y. Calne, who heads a kidney transplant unit at Addenbrooke's Hospital, Cambridge, pointed out this week that more than 6,000 people die each year in road accidents—which should supply more than enough kidneys to meet the demand but few of these are transplanted.

Professor Calne said that the new scheme goes some way towards solving the shortfall. But by itself he does not think that it will produce a great increase in the numbers available for transplantation. Its merit, he said, is that it will make doctors, medical administrators and the public aware that there is a severe shortage of kidneys for transplanting.

FAWLEY BLUEPRINT

Another Blueprint

FUTURE generations should direct their talents towards the biological sciences, according to Professor Dennis Gabor, the 1971 Nobel Laureate in Physics. Professor Gabor, who was delivering the eighteenth Fawley lecture at the University of Southampton last week, on "Proper Priorities of Science and Technology", stressed that society must aim at a state of equilibrium, and that this will be chiefly a biological state.

Professor Gabor's recommendation for a swing to the biological sciences does not mean that "the physical sciences or engineering are at a dead end", but "we need urgently all the help which the biological sciences can give so that we can create a hopeful atmosphere in which all sciences can develop".

This suggestion is part of what Professor Gabor calls an idealistic programme for science and technology, which will work towards a state of stable equilibrium.

Professor Gabor's programme to prevent ecological disaster consists of three parts: avoiding pollution, avoiding waste and developing a technology of equilibrium, topics which are of "increasing importance and difficulty".

Pollution, Gabor says, is a major scandal but a minor problem. All industrial pollution can be suppressed if 1.5 to 2 per cent of GNP is spent by industrialized countries. In almost all cases the techniques to clear up pollution are already available. The motor car industry, however, is "pandering shamelessly to the highly questionable instincts of the public", and in spite of more than 140,000 road deaths worldwide every year, the popularity of the car has not declined.

Waste is present in our society because it is profitable and because it gives employment. The profit can be taken out of waste by forbidding the use of metal for tinned food, allowing only biodegradable containers and allowing fashions to change only infrequently. But, said Professor Gabor, in these circumstances what will the unemployed do? Retraining will help, but is not the complete answer.

The basis of any industrial society is cheap and abundant power; there are still hopes for fusion power but so far it has been a disappointment. Fission power, however, is virtually inexhaustible as techniques for mining low grade uranium are becoming economic. The greatest barrier to full-scale implementation of nuclear power—particularly in the United States—is a "partly rational and partly psychological" mental block; people are scared of nuclear power plants.

Of greatest importance in a state of

equilibrium is food, but the problems of feeding the human race are at this stage mostly technological. The green revolution has ensured that there will be enough food provided that there is enough fertilizer available. But the supply of fertilizers, in particular phosphates, is limited.

The solution to this problem, says Gabor, could lie in photoplankton which is rich in phosphorus. He would like to see specially bred strains of plankton bred for harvesting.

ASTRONOMY

Lockyer's Telescope

"ONE of the finest telescopes ever made" was Sir Norman Lockyer's verdict on his 160 mm Cooke refractor in 1892. With it the founder editor of *Nature* made his spectroscopic observations of the Sun, observed its storms and discovered helium. And now the 110-year-old telescope is to be re-erected eight miles outside Exeter by the Torbay Astronomical Society.

Lockyer first used the telescope in his back garden in Wimbledon in the early 1860s. When he moved to West Hampstead in 1865 he took the instrument with him and from there made most of the observations for which he is famous. In 1884, tiring of West Hampstead, he moved, complete with telescope, to Westgate-on-Sea, where he housed it in first one observatory and then another, before moving yet again to Sidmouth, where he stayed until his death in 1920. The telescope remained at his Sidmouth home until plans were made to move it to the Norman Lockyer Observatory, founded by Lockyer himself in 1913 on a hill above Sidmouth. But the outbreak of war in 1939 resulted in the telescope being buried in the garden of Lockyer's Sidmouth home until the end of the war when it was rescued and restored by the observatory. Lady Lockyer planned to build a dome at the observatory to house the refractor but died before plans were complete, and the telescope simply gathered dust until 1964 when Heles Boys School in Exeter formed an Astronomical Society and the observatory loaned it the instrument.

In 1971 the school decided it had no further use for the refractor. But the Torbay Astronomical Society promptly offered to house the equipment and removed the telescope from the concrete base on which it was mounted at the school. The society is now trying to raise the £700 needed to house and restore the telescope, and plans to re-unite it with its original mounting and drive. Mr A. R. Hutchins, the society's secretary, said this week that about £500 has been raised, and that provided the remainder can be found the telescope should soon be in business again.

NEW WORLD

Belt Tightening in the Office of Space Science

by our Washington Correspondent

A YEAR ago, NASA's Office of Space Science and Applications was divested of its responsibilities for communications and Earth observation programmes and renamed the Office of Space Science. But the reduction in responsibilities has not been matched by a reduction in problems. Far from it. During the past year, officials in the Office of Space Science (OSS) have been forced to take uncomfortable decisions, engage in difficult planning tasks and re-evaluate their priorities. The reason is simple: acute and chronic shortages of money.

Considering that the office got all the money it requested from Congress for the 1973 fiscal year (which started on July 1) and that none was withheld by the Office of Management and Budget, the complaint of financial starvation deserves some explanation. The first thing to be said is that the Office of Management and Budget, reflecting public apathy toward space technology, gave NASA a tough time when the budget estimates for 1973 were drawn up. The agency's overall budget was held at about the same level as last year, and it will not be allowed to grow much, if at all, in the future.

This constraint, coupled with the fact that NASA is pressing ahead with development of the Shuttle, forced a close re-examination of the timing of some projects, to try to damp down yearly oscillations in the agency's budget. For the OSS, it has meant that some projects have had to be terminated and others scaled down or delayed—most noticeable casualties in the 1973 budget were the Grand Tour of the outer planets, which was scrapped and replaced by more modest flybys of Jupiter and Saturn, and the Orbiting Solar Observatories programme, in which OSO-J and OSO-K were deferred. But the chief acute headache in OSS during the past year has been a cost overrun of some \$35 million in the launcher development and procurement programme.

The problem stems mostly from the failure of four launchers in 1970 and 1971—two Deltas and two Atlas-Centaur. The Delta failures resulted in the loss of a meteorological satellite developed by the National Oceanic and Atmospheric Administration and the placing into a wrong orbit of OSO-7, while the failures of the Atlas-Centaur rockets caused the loss of an astronomy satellite, OAO-B and Mariner-8. The failures prompted an exhaustive review of both launchers which led to improve-

ments designed to ensure that their instrumentation would survive the gravitational and other stresses to which they may be subjected in individual launches. This upgrading took place with 1973 funds.

Another problem was that the agency ran into technical difficulties in developing a computer for improved guidance for Delta and Atlas-Centaur launchers, which resulted in some unbudgeted costs. And, finally, NASA underestimated the

number of reimbursable launches that it will be performing in the 1973 fiscal year.

Mr Joseph B. Mahon, Director of the Launch Vehicle and Propulsion Program, said last week that he is optimistic that the problems have been solved, because there have so far been four successful Delta launches with the new computer guidance system and, although it will not be flight tested until the launch of an Intelsat satellite next

PLANETS

Second Thoughts on Venus

by our Washington Correspondent

OFFICIALS in NASA's Office of Space Science have been forced during the past few weeks to re-examine their plans for exploring Venus. Because of budgetary constraints, they have decided to drop one of the two launches that was due to send atmosphere probes to Venus in 1977. The other launch is still, however, planned to take place on schedule and it will probably be followed by an orbiter in 1978. Options are also being kept open for the next launch window in 1980. Previous plans would have sent two sets of probes to Venus in 1976/77, an orbiter in 1978 and probably another probe in 1980. NASA is also considering making the orbiter a joint mission with ESRO.

The reasons for the change are mostly financial — dropping one probe launch will cut the costs of the programme from some \$200 million to about \$150 million—and it is hoped that the reduced programme will be more palatable to the Office of Management and Budget. So far, the Venus-Pioneer programme has not received Executive or Congressional Approval, but NASA will be asking for funds for the next fiscal year. The change will, however, also add flexibility to the programme, for the idea now is to use the dropped probe launch as a backup for the 1980 launch window, to re-run either the other probe or the orbiter should they fail. Another possible alteration in the programme is that NASA is studying the possibility of launching the spacecraft on an Atlas-Centaur instead of a Delta rocket to see whether the removal of size and weight constraints on the spacecraft

would offset the extra costs of the more powerful launcher.

Planetary scientists contacted last week greeted the news of the changes with mixed feelings. Dr Carl Sagan, of Cornell University, said that in view of the other demands on money in the OSS budget he agrees with the decision to scale down the Venus-Pioneer programme. He pointed out that the Soviet Union already has an advanced study programme of Venus under way and suggested that within five years Soviet spacecraft would have sent buoyant probes into the Venusian atmosphere and perhaps even have television pictures of the surface. For the US to follow on the heels of the Soviet programme at the original level of expenditure would therefore be "a serious waste of funds".

But Dr Michael McElroy of Harvard University was more disturbed by the news. He pointed out that the dual launch was suggested for two chief reasons—first, there is a high risk of failure, and therefore to send two sets of probes would increase the chances of success, and second, if they are both successful, there would be increased planetary coverage and additional scientific return. He added that he is "totally opposed" to the argument that the US need not study Venus intensively because the Soviet Union already has an advanced programme. He said he is "impressed by the fact that the list of objectives for Venus remains essentially unsatisfied by the Soviet programme", and that in any case it does not make sense to "give away a field of scientific study to another country".

month, the improved Atlas-Centaur has been doing well in tests. The problems have, however, starved the rest of the space science programme of \$35 million during the present fiscal year, and this, coupled with the need to keep future funding steady, has caused some major changes to individual projects.

● The first two scheduled launches of the High Energy Astronomical Observatories (HEAOs) have been put back, the first by 11 months and the second by seven months. HEAO-A will now be launched in 1976 and HEAO-B in late 1977.

● The launching of the next satellite in the Interplanetary Monitoring Platform series, IMP-J, has been "indefinitely deferred".

● The launching of an improved X-ray satellite, SAS-C, has been delayed. It was scheduled for launch in late 1974, but a new launch date has not yet been decided.

● The next Orbiting Solar Observatory, OSO-I, was at one time on the chopping block, but NASA has now decided to go ahead with the launch. An announcement on the fate of the next two in the series, OSOs J and K, will be made when the 1974 budget is unveiled in January and NASA officials are reluctant to comment at this stage. Their chances of survival are, however, considered slim.

● The planned Venus-Pioneer missions have been trimmed to save about \$50 million in the total cost of the project (see page 177).

Explaining the changes in the space science programmes in an interview last month, Dr John Naugle, Director of the Office of Space Science, said that the delay in launch of HEOS-A and HEOS-B will account for much of the \$35 million overrun with a minimum of impact. Contracts for development of the two spacecraft have recently been awarded to TRW Systems Inc., and by delaying the programme now, NASA hopes to avoid unemployment and the decision will also circumvent having to scrap other projects which have been authorized. The HEAO programme was, however, given top priority by the Space Science Board of the National Academy of Sciences in a report last year, and Dr Naugle said that "it is still one of the highest priorities" in NASA. He warned, however, that "it is not out of the realm of possibility that we will still have to make further changes in the programme".

As for the other two planned high energy astronomy satellites, they are expected to be early shuttle launches in the late 1970s and planning is going ahead on the assumption that they will be given the green light. In the meantime, however, X-ray and gamma ray astronomy is being carried out by the small astronomy satellites, SAS-A and SAS-B. The next

in the series, SAS-C, will be an upgraded X-ray astronomy satellite, which will carry on the work of the highly successful Uhuru spacecraft and it would be desirable to have the results from it well before HEAO-A is launched. Dr Naugle said that OSS is "doing everything to minimize the slip in the SAS schedule" and he added that a fourth satellite in the SAS series—an International Ultraviolet Explorer, to investigate the ultraviolet band of the spectrum—"looks very good". The satellite will be a joint undertaking between ESRO, the UK and NASA.

Another likely casualty of budgetary stringencies in NASA, IMP-J, would have been a companion spacecraft to IMP-H, which was launched recently (see *Nature*, 239, 186; 1972). It would have carried out experiments and measurements on the magnetosphere, the solar wind and cosmic rays. It is hoped, however, that the likely cancellation of IMP-J will not also bring down the proposed NASA-ESRO magnetosphere explorer, IMP-KK', which will be designed to carry out studies of the magnetosphere and its interaction with the solar wind. The mission is planned to consist of three satellites, a so-called mother-daughter system, and a heliocentric spacecraft which will sample the incoming solar wind while the others take measurements of the magnetosphere. The mission is designed to provide information on the relationship between solar flares and magnetic storms around the Earth. Agreements between NASA and ESRO have been worked out, and Dr Naugle said that he expects IMP-KK' to proceed "as a part of the ongoing programme". Launch of IMP-KK' will probably take place in the late 1970s.

Other physics and astronomy programmes in OSS, apart from the solar observatories series, seem to have fared better during the budgetary squeeze this year. The Atmospheric Explorer series is proceeding on schedule, with launches planned for next year and in 1975, and Dr Naugle said that he hopes to maintain the Explorer-class missions "at about the same level as they are now". Further ahead, NASA is making detailed plans for the proposed Large Space Telescope—an optical, diffraction-limited telescope which will be launched and refurbished by the shuttle. First launch is set for about 1980 and, although the first telescope would not be truly diffraction-limited, it would be replaced within a few years be an upgraded instrument. The plan is for the large space telescope to be an international facility which would be available, with shuttle refurbishing, for between ten and twenty years. The cost has not been fully worked out, but some astronomers are estimating that it would be in the region of \$250 million.

As for NASA's planetary programmes, belt tightening is going on there as well. The most obvious casualty of budgetary stringencies in the past year was the dropping of the Grand Tour of the outer planets and its replacement with two Mariner-class missions to Jupiter and Saturn to be launched in 1977. Although the reduced programme has been warmly endorsed by space scientists, there is still some chagrin because the unique alignment of the outer planets, which would have allowed spacecraft launched in the late 1970s to flit past them all, will now be missed. There is some hope, however, that a Jupiter-Uranus flyby may be attempted with a Mariner spacecraft in 1979, and NASA has such a mission under study.

Other approved programmes—the Viking, Mariner Venus-Mercury flyby, Pioneer-Jupiter flybys and Helios missions—are proceeding according to plan. But for the 1974 fiscal year, NASA will be putting in for funding for some new starts, chief of which will be the Venus-Pioneer programme and the two Mariner flyby missions to Jupiter and Saturn. Already budgetary restraints have caused the Venus-Pioneer programme to be scaled down in size, and planetary scientists will be anxious to see that both are preserved from OMB's axe.

Dr Michael B. McElroy, of Harvard University, said last week, for example, that "if the 1974 budget does not include a Venus Pioneer and the Mariner (Jupiter-Saturn) mission, then it would be almost a fatal blow to the planetary programme". These sentiments were also echoed by Dr Francis Johnson of Texas University, who said that although the planetary programme is "developing very well as it is now envisioned", it would get seriously out of balance if further inroads were made in the Venus Pioneer programme.

Further ahead, NASA is actively studying the possibility of sending atmosphere probes to Saturn, and also spacecraft to take a close look at comets. Jupiter is also a prime candidate for further study when the preliminary results come in from Pioneers F and G, but as yet the hazards to orbiters and probes from the Jovian radiation belts are not yet known. Further studies of Mars will also be on the cards after the Viking landers have visited the planet.

Clearly, however, the future for much of the space science programme is now being shaped by tradeoffs between NASA and OMB to determine the level of the agency's 1974 budget. Scientists will be anxious to see whether the overall constraint that the space budget must be kept constant, coupled with the increasing expenditure on the shuttle programme, will damage space science. All will be made clear in January, when the Administration unveils its budget.

NEWS AND VIEWS

Do All Supernovae Beget Pulsars?

It is odd that the Crab Nebula is still the only supernova remnant definitely associated with a pulsar. Or is it? This question will be pondered by many astronomers following the announcement this week of another possible association—but, like several other suggested associations, not definite—between a pulsar and a nearby supernova remnant. On page 229 of this issue of *Nature*, Davies, Lyne and Seiradakis report the detection of a pulsar about 0.6° from the centre of a supernova remnant which itself is about 0.7° across. In addition to the positional propinquity, the age of the pulsar estimated from the rate of rundown of the pulsations is not a bad match to the age of the supernova remnant as estimated from its appearance.

This must now be added to the possibility of an association between a patch of radio emission four or five degrees across in the southern hemisphere constellation Vela, widely suspected to be a supernova remnant, and a pulsar situated about one degree from the centre (Large, Vaughan and Mills, *Nature*, **220**, 340; 1968). Another possible association, between a supernova remnant in Crux and the pulsar PSR 1154-62, is expected to be published soon.

So, of the scores of pulsars now known, the number of links with supernova remnants boils down to one definite and three possibles. Yet almost since the discovery of pulsars it has been a credendum that pulsars are formed phoenix-like in the ashes of stars which have otherwise totally disintegrated in supernova explosions. Why, then, are there not more definite associations between pulsars and supernova remnants, and do all supernovae indeed lead to the formation of pulsars?

Professor A. Hewish of the Cambridge radio astronomy group addressed himself to the latter question at last week's meeting in London of the Royal Astronomical Society, and described his answer as "a qualified yes". Professor Hewish's chief approach was a statistical one, from which he arrived at a roughly one-to-one relation between the number of pulsars in the neighbourhood of the Earth and the number of supernova remnants having the same range of ages.

To begin with, it is necessary to decide how far back in time the search must be taken. The ages of pulsars can be estimated from the ratio of the pulse period (P) to the rate at which the period is lengthening ($\dot{P}$), although here it is, of course, necessary to assume a model for the nature of pulsars. Professor Hewish said that the ages of twenty-seven pulsars for which the rate of run-down can be measured are fairly tightly clustered around a mean of 5×10^6 years—three pulsars are younger than 10^6 years and three are older than 5×10^7 years. Pulsars older than about 10^8 years are believed to be too weak to be detected.

Pulsar distances are estimated from the degree to which the lower frequencies in the signals are delayed by electrons in the interstellar medium (which requires an assumption to be made about the interstellar electron density) and, occasionally, by examining the 21 cm emis-

sion from pulsars for signs of absorption by intervening spiral arms of the galaxy whose distances are known. Professor Hewish said that of a sample of sixty pulsars, fifty are less than 2 kiloparsecs distant (6,500 light years), ten are at more than 2 kpc and one is farther than 4 kpc.

The most critical assumption comes in estimating what proportion of those pulsars that are near enough to the Earth to give a signal are not detected because the lighthouse-like beam of radiation does not sweep across the Earth. Much depends on the unknown mechanism generating the extremely narrow beams of radiation, but Professor Hewish estimated that the space density of observed pulsars should be multiplied by a factor of between three and ten, with three the preferred value.

The number of nearby pulsars estimated on this basis is said by Professor Hewish to be near enough to the estimated number of supernovae younger than 5×10^6 years to support the view that each supernova leads to the formation of a pulsar. So why are there not more cases of pulsars being identified in the midst of supernovae remnants? Part of the story is that several of the well known remnants that have been attributed to historical observations of supernovae are too distant for any associated pulsar to be detectable. But from the evidence so far it also looks as if pulsars are formed with velocities sufficient to carry them away from the remainder of the residuum of the explosion so that it becomes difficult confidently to link a pulsar with a nearby remnant. Observations of the effects of interstellar scintillations on pulsar signals, for example, indicate pulsar transverse velocities up to several hundred kilometres a second, so that a pulsar will be about 100 pc from its birthplace after 10^6 years. Velocities of this order fit in nicely with the observation that the scale height above the plane of the galaxy is about 140 pc for pulsars, but only 60 pc for the OB stars which are thought to be the precursors of supernovae. Whether the velocities originate in a non-symmetric supernova explosion, or whether they imply that the parent star was originally a member of a binary system of which the companion either disintegrated or was blown away, remains to be elucidated.

It is clear that not everybody will share Professor Hewish's confidence in a one-to-one correspondence between pulsars and supernova remnants—the uncertainties are such that a subclass of supernovae leading to pulsars still seems not to have been ruled out—but whatever its validity the three tentative associations so far recognized seem to fall into a pattern which suggests that those supernova remnants which were formed with a pulsar are profoundly affected by the pulsar. It is well known from Professor Gold's calculations that it is energy supplied by the Crab pulsar that keeps the Crab nebula glowing. But the pulsar seems still to be an influence on the nebula as the pulsar moves away—both the Vela remnant and the Crux remnant are brighter on the side nearest the associated pulsar.—By our Astronomy Correspondent.

Elliot Smith Commemorated

from a Correspondent

HUMAN evolution was the thread connecting the very diverse programme of the symposium to commemorate Sir Grafton Elliot Smith at the Zoological Society of London on November 9-10.

Professor Lord Zuckerman (Zoological Society of London) spoke of Elliot Smith's many scientific interests—fossil hominids; the evolution of the brain and localization of function within it; primate phylogeny; and the development and spread of civilization and culture. The period of influence of Elliot Smith over British anatomy coincided with that of Wood-Jones and Keith, and the interplay between this triumvirate dominated the anatomical scene during the first part of this century. Elliot Smith's involvement in, as it turned out, the fruitless attempts to explain the Piltdown discoveries was touched on by Professor J. Weiner (London School of Hygiene and Tropical Medicine). That the scar which Piltdown inflicted upon physical anthropologists in Britain is not yet healed was apparent as Professor Weiner vigorously defended Elliot Smith against recent allegations that it was he who perpetrated the forgery. It was explained that Elliot Smith had neither the motive nor the opportunity and that there were more plausible candidates for the role of hoaxer.

A presentation by Mr R. E. F. Leakey (National Museums of Kenya) of the programme of research taking place at East Rudolf, Kenya, should help to dispel the reluctance and scepticism (another legacy of Piltdown) with which British anatomists greet the discovery of fossil hominids. Mr Leakey explained that, since the initial exploration in 1968, more than eighty hominids have been found in the sediment which cover 1,000 square miles to the north-east of Lake Rudolf. This work is but part of a larger research programme which includes palaeontological sampling of other animal groups, detailed geological and geophysical investigation of the sediments and archaeological studies. The dating of the sediments is approached in three ways: correlations of the fauna at various levels in the sequence with that of nearby fossiliferous areas, especially the Omo River deposits; potassium-argon methods applied to the volcanically-derived tuffs that are interbedded in the sequence; and palaeomagnetic techniques.

Leakey's team have accumulated evidence of at least two forms of hominid at East Rudolf, but before this year's season both were from beds above the

tuff dated at 2.6 million years. This summer, however, the horizon below the 2.6 million year tuff has yielded a fragmented skull which, after preliminary reconstruction, gives a minimum cranial capacity of 800 cc. Two complete femurs and parts of a tibia and fibula, with morphological features which closely parallel those of modern man, were also recovered from the same horizon. Mr Leakey explained that detailed examinations of this material have not yet been made, but he and his colleagues consider that it is evidence of the genus *Homo*. Remains of *Australopithecus* have also been recovered from this early horizon and the period of co-existence of *Australopithecus* and *Homo* thus extends back to beyond 2.6 million years.

Mr Leakey explained that association of the *Homo* material with artefacts already found at 2.6 million years is a likely hypothesis and that studies of the locomotor implications of the postcranial material will probably widen the gap which is forming between the different locomotor adaptations of *Australopithecus* and *Homo*.

It was to this last subject that Professor M. H. Day (St Thomas's Hospital Medical School) turned. He presented results of a joint anatomical and statistical assessment of hominid lower limb material found before 1972. There now seems to be evidence, Professor Day said, for two bipedal adaptations in the hominids, one for *Australopithecus*, the other for *Homo*; differences between the two could be demonstrated by measurements taken on the femoral neck. Professor Day urged caution on those workers on fossil hominids whose interests were primarily metrical; many fossils are distorted, and casts can be misleading in that they are sometimes made including reconstructed areas of bone, not necessarily marked on the casts as such.

Professor E. H. Ashton (University of Birmingham Medical School) presented the results of an elegant multivariate analytical study of the primate pelvic girdle. Using data from extant groups and from the reconstructed pelvic remains of *Australopithecus*, the results confirm the bipedal gait of *Australopithecus*, but those variables related to muscle actions on the pelvis show the gait to be different to that of modern man.

The second session honoured Elliot Smith's work on the evolution of the brain and the functional organizations of the cerebral cortex and included a review by Dr T. P. S. Powell (Univer-

sity of Oxford) of the evidence for linking functional differences with cytoarchitecturally distinct laminae of the sensory areas of the cortex.

A feature of the contribution by Professor C. E. Oxnard (University of Chicago), in the session devoted to primate phylogeny, was the ingenuity shown in presenting multidimensional data in a bivariate form. Dr R. D. Martin (University College, London) reminded the meeting of the pitfalls when taxonomic organization is mistaken for a phylogenetically derived relationship. In a "data packed" presentation, Dr M. Goodman (Wayne State University) showed that the phylogenetic trees that he produces, using the differences between nucleotides coding for proteins and peptides, vary little from those proposed by Elliot Smith in his "Essays on the Evolution of Man".

A discussion on Elliot Smith's stand on the world-wide diffusion of culture from Egypt ended a symposium which successfully reflected Elliot Smith's catholic scientific interests and the wide and sustained influence his ideas enjoyed.

ARCHAEOLOGY

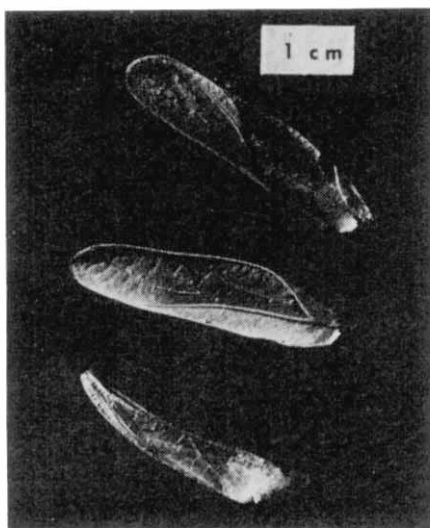
New Finds at Border Cave

from a Correspondent

Johannesburg, November

THE history of modern man's early occupation of southern Africa has already been substantially rewritten as a result of excavations at Border Cave, a site set high on a scarp on the borders of Swaziland and northern Natal. The most recent finds there suggest that a new and important chapter is about to be added to that history. During the past two years a team led by P. B. Beaumont of the Bernard Price Institute for Palaeontological Research in Johannesburg has unearthed extensive and remarkably well preserved remains of animal and vegetable matter, the age of which ranges from the present to 40,000 BC and may well date back to 70,000 BC.

Indicative of the unique state of preservation of these specimens are delicate insect wings and bird feathers. Examples of the vegetation found are leaves, twigs, nuts and grass matting. The grasses, some of which seem to have been specially selected for the purpose, may well have served as bedding material. A particular feature was the finding of hair of various antelope. The presence of animal hair suggests that human hair might also eventually be



Insect wings found preserved at Border Cave.

identified, the nature of which should then be relatively easily determined. Of potential interest is the finding of a maize cob of primitive type. The dating of nearby objects at the same stratigraphic level promises to resolve the problem of whether maize was introduced into Africa south of the Sahara before or after the time of Columbus.

The cave was first discovered by R. A. Dart in 1934 (H. B. S. Cooke, B. D. Malan, and L. H. Wells, *Man*, **3**, 22; 1945). Subsequent investigations of this site and others in adjacent Swaziland have provided evidence that *Homo sapiens sapiens* already inhabited southern Africa before 47,000 bc and that the mining of haematite was one of his activities as long ago as 42,000 bc (R. A. Dart and P. B. Beaumont, *S. Afric. J. Sci.*, **67**, 7; 1971).

The dating and classification of these latest finds represent an enormous labour and are necessarily still at a very preliminary stage. Beaumont has so far recovered tens of thousands of grams of the dried vegetable matter and hundreds of thousands of bone and mineral artefacts. Even so, hundreds of cubic metres of intact deposit remain for examination, and the archaeologists are confident that even greater treasures will be excavated if the necessary support is forthcoming.

Unfortunately the scale of the work and the location of the cave now pose various difficulties which must quickly be overcome if this work is to continue and the site preserved for archaeological purposes. For one thing, the cave is located within the borders of a Bantu reserve; access to the territory is not therefore without its problems. Another difficulty is that local tribesmen show an inclination to use the shelter of the cave for their goats.

In spite of the considerable help being received internationally, the study calls for a much greater degree of sup-

port in the way of funds and expertise is urgently needed. Should it be forthcoming, there is every chance this site will provide unique information bearing on the genesis of modern man.

CHROMOSOMES

Where the Genes Are

from our Molecular Biology Correspondent
THE arrangement of genes on the eukaryotic genome, and the manner in which they are selected for transcription, is the subject which perhaps more than any other at this moment in time sends the caesium chloride coursing through every true molecular biologist's veins. The central enigma, so to speak, in the field is the significance of the copious repetition of certain genes within the DNA molecule.

A group of new articles on the subject proffer some interesting new findings, though no answer to the question. Suzuki, Gage and Brown (*J. Mol. Biol.*, **70**, 637; 1972) have considered the possibility that cells dedicated to the manufacture of large amounts of a single protein may also be endowed with many copies of the corresponding gene. The expected answer, it must be owned, to judge at least from published work on several systems, is no, but Suzuki *et al.* have put it to the test in elegant style. The silk gland of the silkworm not only makes silk fibroin, but also in the course of differentiation accumulates a large mass of DNA. Thereafter the cell enters into its specialized function of synthesizing what is essentially an alternating copolymer of alanine and glycine. The messenger, loaded with the

corresponding codons, is unusually rich in guanine, and has recently been isolated and analysed by Suzuki and Brown. Being so extreme in composition the silk fibroin gene separates from the bulk of the DNA in an equilibrium density gradient.

So as to maximize the separation of this small fraction from the rest, silver ions were introduced, which bind to A-T base pairs, causing a shift towards higher buoyant densities. When radioactively labelled, purified silk fibroin messenger was hybridized with sheared DNA, a maximum of radioactivity appeared in the expected part of the density gradient, displaced from the peak of total DNA absorbance. This effects a crucial discrimination from contaminating ribosomal gene hybrids, which are present in vastly higher concentration in the genome. The identity of the hybrid was verified by melting off the RNA and characterizing it in terms of base composition and oligonucleotide digest pattern. A comparison of the concentrations of silk fibroin genes so determined in the DNA isolated respectively from the two kinds of silk gland (middle and posterior), and from the whole animal after removal of silk glands, showed no differences at all. Saturation hybridization experiments, in which the sheared DNA is titrated with radioactive messenger, and the hybrids retained on a filter, led to the result that only 0.0022 per cent of the genome is complementary to the fibroin messenger.

The upshot then is that the fibroin genes are not amplified in the specialized cells, and that (taking into account the estimated molecular weight of the messenger and the total DNA content of the

Mitochondrial Protein Synthesis in Sperm

IN mature bull's sperm synthesis of RNA and protein continues at a low but not insignificant rate. The chromatin of these haploid cells is condensed and presumably metabolically inert. What then is the site of transcription and translation in ejaculated sperm? According to experiments reported by Premkumar and Bhargava in next Wednesday's *Nature New Biology* (November 29) all RNA and protein synthesis in sperm is restricted to the mitochondria.

Premkumar and Bhargava isolated RNA synthesized by sperm in the presence of ^{32}P and then fractionated the labelled RNA using a variety of chromatographic and electrophoretic techniques and *Escherichia coli* carrier RNA. They found that some of the sperm RNA cofractionates with *E. coli* tRNA and in eukaryotic cells mitochondrial but not cytoplasmic tRNAs are similar to those of *E. coli*. Further-

more, some of the sperm RNA cofractionates with *E. coli* 16S and ribosomal 23S RNAs and, of course, the RNAs of mitochondrial ribosomes are 16S and 23S.

These data indicate that both mitochondrial tRNAs and ribosomal RNAs are transcribed in mature bull's sperm but a large proportion of the RNA from sperm is distinct from these species. It must, however, be transcribed from mitochondrial DNA, however, because about 80 per cent of all the RNA made in sperm hybridizes with bull liver mitochondrial DNA and RNA synthesis in sperm is inhibited by rifampicin and acriflavin. Likewise, protein synthesis in sperm is inhibited by chloramphenicol and puromycin but is not inhibited by cycloheximide. In short, these data indicate that all macromolecular metabolism in ejaculated bovine sperm occurs exclusively in mitochondria, a unique situation.

haploid genome) only between one and three copies of the gene are present in each DNA molecule. The accumulation of the product of the cell's activity must therefore be a consequence of exceptionally efficacious transcription of DNA and exploitation of the messenger. Notwithstanding that the gene makes up only 0.0022 per cent of the total DNA, at peak activity, 1 per cent of the total RNA in the cell is fibroin messenger, and this remains functional and undegraded while 10^6 copies of the protein are rolled off in the space of four days. With 10^4 such messengers transcribed from each gene, and 10^6 genes per cell when the total DNA content has reached its maximum, it can be seen that synthetic machinery, working at full pressure, generates a formidable output of its end-product. The specific gene amplification mechanism, however, is still on the cards only for genes whose end-product is RNA, especially ribosomal.

A brief description of such a delicate piece of research leaves the experimental difficulties to the reader's imagination. The complex problems that beset the hybridization approach are apparent in the work of Hough and Davidson (*ibid.*, 70, 491). The RNA molecules that accumulate in the egg cell of *Xenopus* during its development have been found to be derived chiefly from the repeated sequences of the DNA, so that the overwhelming bulk of unique RNA sequences occurs in a very small part of the total. The authors have devised a method of isolating almost intact, by means of shearing, melting and self-hybridization, the repetitive part of the DNA (nearly half the total). When the RNA is hybridized with this material, something in the region of 2-5 per cent is taken up, which is one or two orders of magnitude more than the RNA transcribed from non-repeating DNA. The chief attribute of these repetitive hybrids, which the authors infer from their experiments, is that the sequence matching seems to be rather poor, for thermal dissociation profiles of the labelled hybrids adsorbed on hydroxyapatite showed, even after trimming with ribonuclease, a distinctly low melting temperature—an effect not observed in hybrids of non-repeating RNA—and there is also a hybridized fraction in which the pairing is so poor that it is not retained at all on hydroxyapatite columns. Just how bad the complementarity actually is, at what point a partial match may be regarded as significant, and what purposes this RNA serves anyway, remain in doubt.

An important technical advance comes from Wu, Davidson, Attardi and Aloni (*ibid.*, 71, 81), who have devised a means of extending electron microscope mapping of repetitive genes to those for tRNA, which have hitherto

been considered too short to be directly observable. The strategy is to derivatize the total 4S RNA, introducing a thiol at the periodate-oxidized terminus, by way of a Schiff base linkage with cystamine, which is then reduced. This provides a reactive group for coupling to an electron-dense marker, to wit a bromoacetate-treated ferritin molecule. When HeLa cell mitochondrial 4S RNA, labelled in this way, is hybridized with endogenous DNA heavy and light strands, nine tRNA genes show up on the heavy strand and three on the light. One of the former lies in the spacer region between the 12S and 16S RNA tracts. A similar number of 4S genes (fifteen) has been reported in *Xenopus* mitochondria on the basis of hybridization. How the system manages protein synthesis with a set of no more than twelve tRNAs (supposing that this is what the 4S RNA mostly is) is a fit subject for speculation.

NUTRITION

Fibre-depleted Diets

from a Correspondent

THE role of refined carbohydrate foods in many important diseases characteristic of Western civilization was discussed at a symposium organized by the McCarrison Society at the Royal Society of Medicine in London on October 20.

Dr H. Trowell, who had spent 30 years as a physician in Africa, mostly at Makerere College Medical School, described as "crude fibre" the fraction

of carbohydrate foods which remains after boiling in dilute acid and then in alkali. "Dietary fibre" is the portion of food reaching the colon undigested by enzymes during its passage through the small intestine. It contains in addition to "crude fibre" pentosans which are mostly broken down by bacteria in the large bowel, the bacterial flora and chemistry of which they may largely dominate.

Dr Trowell traced the history of the gradually increasing availability and popularity of fibre-depleted foods both in the Western world and in developing countries. He emphasized the two complementary aspects of consuming refined foods—over-consumption of starch and sugar on the one hand and depletion of fibre on the other.

Mr D. Burkitt (Medical Research Council, London) outlined evidence convincing him that non-infective diseases of the bowel, diverticular disease, appendicitis, cancer, polyps and ulcerative colitis are all related to fibre-depleted diets. All are most prevalent in developed countries, and scarcest in communities deviating least from their traditional dietary customs. The fibre content of food is related to intestinal transit times and to stool bulk and consistency.

Mr N. Plainter (Manor House Hospital) showed from the geographical distribution and historical emergence of diverticular disease—the commonest disease of the large bowel in Western man—that it is the result of a fibre-depleted diet. In most patients symptoms can be alleviated or abolished by administering fibre.

Professor I. McColl (Guy's Hospital Medical School, London) opened the

Inducing C-type RNA Viruses

DURING the past several months groups of RNA tumour virologists in several laboratories have reported the induction of the replication of C-type RNA viruses in avian and murine cells exposed to iododeoxyuridine or bromodeoxyuridine and other mutagens and carcinogens. Furthermore, such C-type particles are released spontaneously by some clones of cells. These findings have strengthened the belief that all avian and murine cells carry the genetic information necessary to specify a C-type RNA virus, the chief tenet of the oncogene hypothesis, and that genetic and environmental factors determine whether or not this potential is expressed. The series of experiments which Todaro reports in next Wednesday's *Nature New Biology* (November 29) are certainly consonant with these ideas.

Todaro has detected the spontaneous

release of C-type particles by clones of spontaneously transformed BALB/3T3 cells. Furthermore, random bred Swiss 3T6 and 3T12 and a line of SV40 transformed Swiss 3T3 cells but not untransformed Swiss 3T3 cells produce C-type virus particles after exposure for 3-5 days to 30 $\mu\text{g}/\text{ml}$. of iododeoxyuridine. All these observations suggest that the probability of the expression of endogenous genes which specify C-type particles is greater for cells that have a transformed cell phenotype and are oncogenic than it is for untransformed non-malignant cells. As Todaro says, "the control system that prevents expression of endogenous type C virus may have been altered permanently in transformed cells". Whether or not the partial expression of this genetic information is involved in spontaneous and chemically induced transformation remains to be seen.

discussion on unavailable carbohydrates in cereals, fruit and vegetables. Dr D. A. T. Southgate's data from the Dunn Nutritional Laboratory, Cambridge, showed a wide range of polysaccharides with different hexose: pentose ratios in various types of vegetables. Potatoes when cooked in their jackets vary greatly in their lignin content according to the cooking technique.

In the afternoon Mr A. K. Adatia (University of Bristol) traced the history and geography of dental and periodontal disease and related them to fibre-depleted foods. High sugar intake promotes bacterial fermentation with formation of acids that subsequently erode the dental enamel. White flour binds the sugar and acids to the teeth. The health of gums and teeth, promoted by mastication of fibrous foods, deteriorates with adoption of soft refined food. He suggested that unprocessed foods contain protective factors which enter the enamel of the teeth during its compression and relaxation on mastication. When sucrose is present in the food it enters the teeth in the same way and encourages the development of cavities beneath the enamel.

Dr Trowell supplied evidence that fibre-depleted diets may play a significant part in coronary heart disease and diabetes. He accepted the evidence relating coronary disease to factors such as fats, smoking and exercise, but suggested that dietary fibre should also be considered.

Dr K. W. Heaton (University of Bristol) outlined the history and geography of cholesterol gall stones which are becoming increasingly prevalent in the Western world. Convincing epidemiological and experimental evidence incriminated refined carbohydrate foods as a causative factor, resulting in increased amounts of bile cholesterol and decreased amounts of bile acids required to keep it in solution.

LOW TEMPERATURE BIOLOGY

Cryosurgical Techniques

from a Correspondent

BIOLOGISTS interested in the effects of low temperature on living tissue and surgeons using cryosurgical techniques in clinical practice met in London on October 27 for a symposium on cryosurgery organized by the Society for Low Temperature Biology.

Sir James Fraser (University of Southampton) opened the meeting by reviewing the uses of extremely low temperature in surgery. He described equipment for its application, outlined the advantages of cryosurgery in certain situations and emphasized the need for more fundamental work on the

nature of the cryolesion, so that a useful tool, which has been used empirically and clumsily in the past, could be applied more accurately and discretely.

Basically, cryosurgery depends on destruction of tissue by temperatures below -15°C . The probes for application consist of concentric tubes, which allow the tip to be cooled by agents such as liquid nitrogen or by expansion of gases such as nitrous oxide. A probe can be passed, for example, into the urethra while warm, then with the tip positioned within the prostate, the gland can be destroyed by freezing. The extent of tissue destruction will depend on temperature drop and duration of application—in other words with probe properties rather than type of tissue to be destroyed.

Three contributors—Sir James, Dr D. K. Whittaker (Welsh National School of Medicine) and Dr H. W. Rothenborg (University of Copenhagen

Rigshospitalet)—presented results of experiments designed to investigate mechanisms of damage within the so-called ice-ball formed around the probe. These studies suggest that cells at the periphery of the ice-ball freeze but are not necessarily irreversibly destroyed and it is almost certain that only tissue which is frozen below -15°C for at least 3 minutes is destroyed. It is thought that most damage is caused by the direct effect of freezing, but it is possible that ischaemia resulting from vascular stasis and an immune response to frozen cells may also be involved.

The other contributors were clinicians who described their experiences using cryosurgical techniques in brain, prostate, skin, nerve, neoplastic tissues, mouth and eye surgery. Clearly the techniques have demonstrated their value in each of these specialities. The advantages are that there is no haemorrhage; scar tissue is minimal so that cosmetic results are good; there is

The Earth's Crust 3,700 Million Years Ago

FOR several years the oldest dated rocks on Earth were members of the predominantly volcanic successions that make up the greenstone belts which are such a striking feature of the Precambrian of southern Africa, Canada and Western Australia. Last year, however, it was reported that quartzo-felspathic rocks of granitic composition from an area in West Greenland are more than 3,700 million years old.

In next Monday's *Nature Physical Science* (November 27), Moorbath, O'Nions, Pankhurst, Gale and MacGregor describe further work on a large collection of material from the region in West Greenland where reconnaissance had shown the presence of rocks older than any other terrestrial material yet dated. The new data confirm the great antiquity of these granitic gneisses, which are shown to have formed more than 3,700 million years ago. The areas from which these very old rocks have survived have escaped a rather widespread metamorphic event which affected many other regions where Precambrian rocks are exposed at present in the Northern Hemisphere.

It seems quite likely that this metamorphic event, which occurred about 3,000 million years ago, has largely obliterated the earlier history of these regions, which include much of east Greenland, north-west Scotland and parts of the Soviet Union. If a means of penetrating this obscurity can be devised it may emerge that much of the granitic crust is at least as old as that of the west Greenland area. No doubt

this question will be cleared up in the next few years, but the importance of the work now reported is that it demonstrates that granitic crust had already formed early in the history of the Earth and that this event took place before many of the greenstone belts evolved. In other words, a picture of the early crust is emerging in which a granitic crust, developed perhaps by a primary differentiation of the planet, evolved in time to form a basement on which numerous piles of volcanic rocks were to accumulate later in the Precambrian.

The work of Moorbath and his colleagues at the University of Oxford is also throwing some light on the isotopic make-up of strontium in the early crust. As Moorbath pointed out recently at the annual meeting of the American Geological Society (*Abstracts Volume, 1972 Annual Meeting of the Geological Society of America*, 599) it is often assumed that the observed strontium isotope ratios are solely related to the source region of a given igneous rock.

In fact work such as that reported on the west Greenland rocks strongly indicates that the observed ratios reflect the sum of many processes which have affected the rocks, such as the differentiation of melting of mantle material, the partial melting of continental crust, the contamination of magma by country rocks and a variety of wall rock alterations. In the light of Moorbath's warning it may be necessary to be more cautious in the future in interpreting strontium isotope ratios.

immediate immobilization of cells, so that there is minimal disturbance of neoplastic cells; and the low temperature acts as its own anaesthetic. The fact that freezing damage is unselective means that nerves supplying the area are also destroyed—hence the extreme pain associated with some tumours could be relieved. It was emphasized that although the technique is a useful tool in treating benign tumours and can be valuable in relieving pain as part of the management of massive recurrent malignancies, it is in the second instance a palliative treatment only and should not be proclaimed as a cure for cancer.

SOLID STATE

Hard and Soft Bubbles

from a Correspondent

MAGNETIC bubble technology seems to have survived what could have been a serious setback—the discovery of the so-called “hard” bubbles, which have undesirable properties. A magnetic bubble is a cylindrical magnetic domain (diameter and length $\approx 5 \mu\text{m}$) magnetized along its axis; it can be formed in thin epitaxial layers of certain mixed or substituted rare-earth iron garnets. A suitable bias field, directed antiparallel to the magnetization of the bubble, maintains it at a constant diameter. By the use of overlaid patterns of conductors or soft magnetic material, magnetic bubbles can be replicated, translated and detected. Such operations render bubbles useful for serial digital storage, and solid state bubble domain stores will probably provide severe competition for the widely used electromechanical magnetic disk and drum stores.

A stumbling block was, however, identified by workers at Bell Telephone Laboratories (*Bell Syst. Tech. J.*, **51**, 1427; 1972) and at IBM (*Appl. Phys. Lett.*, **21**, 149; 1972), who reported the existence of a new form of magnetic bubble, namely the “hard” or “quantized” bubble. The hard bubble (as distinct from the normal or soft bubble) has many disadvantageous features: its diameter in a bias field is larger than that of a soft bubble; it can exist at different diameters (that is, it has levels of hardness); its mobility is much lower than that of a soft bubble and, instead of moving parallel to a field gradient, it moves at an angle to the gradient (at 80° in one material). From the standpoint of devices, the most worrying property of hard bubbles is their spontaneous formation during normal circuit operation, which leads to failure of the memory.

The properties of a hard bubble are

now thought to be related to the structure of the 180° domain wall ($\approx 300 \text{ nm}$ wide) which divides the bubble from the surrounding domain (*Phys. Rev. Lett.*, **29**, 946; 1972). Within the simplest domain wall—a so-called Bloch wall—the magnetic moments of the magnetic ions lie in directions which gradually change from one side of the wall to the other. Halfway through the thickness of the bubble domain wall, the magnetic moments are circumferential and in the plane of the epitaxial layer. The arrangement of the magnetic moments in such a wall resembles the steps on a spiral staircase and can be right or left handed. The domain wall of a soft bubble is thought to have this kind of structure.

A hard bubble, on the other hand, probably has a domain wall comprising segments of Bloch walls—alternately right and left handed—separated by Néel wall segments. The arrangement of the magnetic moments in a Néel wall is quite different from that in a Bloch wall: in particular, the magnetic moments halfway through the wall are radial. And Néel walls, like Bloch walls, can be right or left handed. Segmented domain walls have not been observed directly in garnets, but Professor Tebble and his colleagues at the University of Salford have detected such walls in thinned cobalt foils using the technique of Lorentz electron microscopy.

The suppression of hard bubbles in materials likely to be used in practical devices presented a serious problem, but one which seems to have been

overcome in two ways by workers at Bell Laboratories. The first technique (*Bell Syst. Tech. J.*, **51**, 1431; 1972) uses a structure involving a double or triple magnetic garnet layer. A high magnetization layer capable of supporting bubbles is grown onto a low magnetization layer which itself has been grown onto a non-magnetic garnet substrate. The presence of the low magnetization layer, which is saturated by the bias field, provides a domain wall cap to the base of the bubble and leads to the exclusive formation of bubbles with walls which have two Néel and two Bloch segments. Such a bubble is the softest of the possible range of hard bubbles and behaves as a normal bubble.

The second technique for the suppression of hard bubbles (*Bell Syst. Tech. J.*, **51**, 1436; 1972) makes use of the implantation of hydrogen ions in the surface layer of the garnet. Such implantation causes an easy axis of magnetization to form in, and parallel to the plane of, the implanted garnet layer. The effect of the in-plane magnetization is to put a lid on a bubble domain and this leads to the formation of the “soft” hard bubbles as in the double layer technique.

Although the immediate problem of suppressing hard bubbles seems to have been solved, the two suppression techniques may create other problems in the manufacture of devices; in particular, the presence of an in-plane magnetization layer in a garnet with ions implanted will probably make bubble detection more difficult.

Black Hole Energy Extraction Problems

THE entertaining idea of extracting gravitational energy from a black hole by steadily lowering things into it—put forward not too seriously by Penrose a few years ago—is shown by Gibbons in next Monday's *Nature Physical Science* (November 27) to encounter insurmountable practical difficulties. Gibbons takes account of the stress on the rope used in such a procedure, and finds that the rope would break before any worthwhile amount of energy could be extracted.

If practical problems are ignored, the region of space around a black hole offers an apparently almost limitless supply of energy, because a particle lowered into a black hole could do gravitational work of up to mc^2 on apparatus at the other end of the constraining rope. This rather rapid glossing over of the process, however, conceals the fact that no account has been taken of the rope itself—what has really been suggested is that a particle be lowered into a black hole

using a rope of negligible mass which is not affected by the peculiar properties of space-time around a black hole.

Gibbons has considered a more practical rope, made up of particles which each have their own four-velocity and define their own paths through space-time. Even an idealized rope must break before the particle being lowered reaches the ergosphere of the underlying hole, where its weight becomes infinite; for a non-rotating black hole the particle can be lowered to no closer than 1.14 Schwarzschild radii, and the energy extracted can be no more than 63.2 per cent of mc^2 . Even worse, for a practical rope (Gibbons considers one made of piano wire) breakage will occur much sooner. In fact, no more than $\sim mc^2 \times 10^{-12}$ could be extracted—something like 100 J for each gram of matter—and the rope could be lowered no closer than 5×10^{11} Schwarzschild radii. This seems to rule out black holes as practical sources of energy.

SURVEY OF JAPANESE SCIENCE

Prospects for Science in Japan

ONE of the reasons why the organization and conduct of science in Japan absorb the interest of people elsewhere is that, at least from the outside, it seems as if the Japanese government has managed to solve the problem which preoccupies governments elsewhere in the world—how best to ensure that funds invested in science and technology will be economically and socially beneficial. For is it not now plain that in the past few years the economic success of Japan as an exporter has depended on an outstandingly efficient application of comparatively pedestrian technology to the manufacture of products now widely recognized to be technically superb and cheap as well—television sets, for example? And outside Japan, it is so apparent that these marvels are not accomplished by the paying of low wages—so far as comparisons can be made between communities so different, personal incomes in Japan are not much different from those in most of Western Europe even if academics have cause for complaint—that outsiders have been driven to the belief that there is something special, enviable and desirable about the utilization of science for economic ends in Japan.

In the articles which follow, there is much to make more rounded this simple external impression. Mr Y. Nakasone, the most powerful influence on the administration of science and technology in Japan, in part because he is Minister of State for Science and Technology in Mr Tanaka's new government, but also because he is, as well, the head of the Ministry of International Trade and Industry, has very little to say about television sets. Instead, he is much more concerned with the ways in which the scientific enterprise can be used domestically in Japan. He writes of what the Americans call health care delivery, the need to improve and even understand the environment and the need somehow to be able to predict the consequences of new technology. To the extent that Mr Nakasone's ideals are different from and even orthogonal to those of many of his predecessors, this is a reflexion of how the government that came into power less than six months ago is unexpectedly adventurous. The air route between Tokyo and Peking must now be almost as busy as that across the North Atlantic, which is a striking measure of how circumstances have changed. Some might say that Japan is now strong enough to have a foreign policy of its own but what Mr Nakasone says is that the time has also come when it should be possible to harness science and technology to the needs of people who live there, not simply to the demands of the markets overseas.

There is no reason to think that these new ideals will be frustrated—on the contrary, if the government of Japan is able to turn its technological energies towards the needs of its own people, it will find that it has done much to ease some of the political conflicts within Japanese society, especially the alienation of the extreme left from the governmental process. That is also a worthy goal. What people elsewhere could ask themselves is whether the speed with which it has been possible to reorient the pattern of manufacturing industry in Japan may not presage an equally remarkable reorientation of the dis-

posal of priorities in the application of science and technology to social needs. Will visitors from outside, twenty years from now, be beating a path not to the Ministry of International Trade and Industry and its institutions but to the citadels of what Mr Nakasone calls the soft sciences?

The answer depends in part on great imponderables which have puzzled occidental sociologists for decades. Why is the Japanese family spirit so easily translated from the home to the office or the factory? Why, in any case, are the Japanese so reliable? But there are also explanations of a more familiar kind, chief among which is that exemplified by the procedures used in the past decades by the Minister of International Trade and Industry for deciding how to spend public money on technological developments and the machinery then devised for spending the money. One of the most distinguished of all the applied research laboratories in Japan is the Electrotechnical Laboratory in Tokyo, financed by the government and deeply involved not merely in plans for pattern recognition but also in schemes for helping Japanese manufacturing companies to compete still more effectively with manufacturers elsewhere. But the Electrotechnical Laboratory is a pensioner of the Ministry of International Trade and Industry and is one of the agencies by means of which the government can talk to industry about the industrial strategy that Japan should pursue. As enterprises of this kind go, it is a smallish laboratory—just under 600 of its members are engaged in research. On page 204, the director of the laboratory, Dr F. Mori, explains how the system works and how he considers that some of its success derives from the Japaneseness of the Japanese.

But there is a little more to it than that. The Ministry of International Trade and Industry is a powerful govern-

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ment department and its complex of research institutions sits comfortably in between government and commerce in a way that is unrivalled elsewhere. The result is that the laboratory and industrial companies are able between them to devise schemes for investing money in research and development which are potentially profitable and which are often unambitious in that they require no long-term programme of research and development to make them succeed (but the Pattern Information Processing System Project described on page 212 is far from unambitious). The result has been that the laboratories of the Ministry of International Trade and Industry have become the places at which a balance is struck between technological ambitions comparable with those which lead to projects such as the Apollo programme and the more modest concern of businessmen with the balance sheet.

At the same time, it is only fair to acknowledge that even the Japanese can make mistakes. Many attempts in the past few years to make the Japanese aircraft industry competitive with those elsewhere have not been conspicuously successful. Dr H. Shima's electric railway between Tokyo and Osaka is every bit as marvellous as he says, but it is hard to see how the principles on which it works will become either dollar earners or a precedent for what is done elsewhere. And there is much at this stage evidently uncertain and even over-adventurous in schemes such as that nurtured in many parts of the Japanese government for setting up a strictly Japanese satellite system or for the exploitation of what is called under-sea technology. It will be interesting to see how these separate and often conflicting claims on the public purse find a satisfactory balance among themselves.

The outstanding record of success in applied research, in part at least a product of a willingness to settle for modest objectives, is by no means mirrored by the condition of basic research. One of the most striking features of science and technology in Japan is the contrast between the confidence and the adventurousness of the applied research establishments and the depression of the universities, in many cases shamefully and needlessly starved of money. Yet the world knows that the contributions of Japanese scientists to the advancement of knowledge have in the past half century been of the highest quality and of great influence. Did not Yukawa invent the concept of the meson, after all? Among the articles which follow are those in which Professor S. Ebashi describes the contribution of "Japanese scientists" to the experimental investigation of the relationship between calcium ions and muscle contraction without mentioning that he was one of those principally concerned, and that in which Professor Hidaka describes the development of oceanography in Japan in the past decade. Both of these are typical of the tales which could be told of how individual Japanese scientists have contributed marvellously to basic research. What is not appreciated outside Japan is that the people concerned are often compelled to work in universities which are exceedingly impoverished by the standards to which academics have become accustomed elsewhere. Indeed, if Japanese technology has an Achilles' heel, it must surely consist of the disastrous gulf there appears to be between the universities, on the one hand, and industry and some parts of the government on the other. Only in Japan is it possible to find civil servants declaring that the universities are too effete to contribute to the Japanese

economy and to the development of Japanese society. Only in Japan is it possible to find industrial companies saying quite openly that they will recruit scientists not at the end of their university careers but on leaving high school, with the intention of educating them on the job.

Why have the universities become so downtrodden and what can be done to remedy their circumstances? The vast expansion of higher education in Japan in the past few decades has not been matched by a sufficient loosening of the procedures by means of which universities are administered. The university system has grown from the handful of ancient imperial universities, the University of Tokyo prominent among them, which now constitute a kind of Ivy League. Altogether, there are some thirty-five universities supported directly by the central government and an equal number supported by municipal and prefectural authorities. But then there are private universities at which students pay high fees and where the university administrations attempt to balance their books with the help of research contracts with commercial interests, benefactions from companies and the stratagems for financial survival which are now familiar to the presidents of private colleges in the United States.

Professor Kakiuchi has much to say about the way in which, in the publicly-supported universities, professors (appointed in the last resort by the government) are given an essentially fixed complement of staff—an associate professor and two or three research assistants. One of the causes of discontent in the universities is that the rigidity of this system implies that opportunities for promotion are not nearly sufficient to satisfy the ambitions of younger academics, while in a great many university departments the professor is still regarded as a kind of god. Where research in the publicly-supported universities is concerned, each university professor is given an allocation of funds by the Ministry of Education which is at once too small to support an ambitious research programme, which does not vary with the needs of individual professors nor with the quality of their research, and out of which in any case they are expected to pay a contribution to the university's running overhead. The Science Council of Japan, a unique institution which is formally elected by Japanese scientists but which is financed by the Science and Technology Agency and given an allocation of funds to distribute to university researchers, seems always to be saying that it should spend the limited sums at its disposal with great discrimination, but seems in practice to spread its largesse so thinly that few university researchers derive much benefit.

The government's solution to the problem of the impoverishment of university research in the public universities has been to create a number of special research institutes in close association with universities—Professor Kakiuchi's Solid State Physics Institute is such a one—and although the result has been not merely a stimulus for fundamental research but the fostering of a strong tradition of applied research in many universities, the system has also driven a wedge between the scientists attached to institutes and those who struggle on with the stipends provided. It is remarkable that the Japanese authorities have been able to avoid the solution to this problem adopted in most other scientifically advanced communities—the creation of a grant-giving body (such as the Science Research Council in Britain) which sets out to dispense substantial sums of money to those who can make a case for spending it well.

The Way Ahead for Japanese Science Policy

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Mr Nakasone, Minister of State for Science and Technology, puts forward the view that the "soft" sciences will have to be encouraged more strongly in the future.

THERE is no need to dwell on the benefits accruing to mankind from science and technology. Yet in spite of the great strides forward that have been made in recent years, man has often found it impossible to bring science and technology under his complete control. In some cases, he seems like the fabled "magician's apprentice" who, using some of the magic partially learned from his master, finds that he has committed a serious blunder because he had not learned how to break the spell.

Environmental pollution is a case in point. Chemical substances like PCBs are products of the latest chemical technology. They have been used industrially without a full understanding of their effects on man and other living organisms. These chemicals have been widely scattered throughout the environment in the form of dumped wastes, and, as a consequence, have polluted the environment and have seriously affected man and other forms of life.

Such examples have cast doubt on the value of science and technology, and many people wonder whether the advance of science and technology will bring real happiness to mankind. As we are not strangers to notions of progress and prosperity, we can neither revert to the life of ancient times nor content ourselves with the stagnancy of mediaeval times. On the contrary, we have so successfully employed science and technology in solving problems which baffled our ancestors that we now seek to solve all problems with these methods. Tuberculosis was once regarded as an incurable disease. People simply left its victims to fate. But when cures to such diseases were found, people began to expect science and technology to conquer such diseases as cancer—diseases far deadlier than tuberculosis. Such concepts are natural to man. And, indeed, it may be the task of science and technology (or science and technology policy) to meet such social demands. Briefly, the underlying concept of science and technology policy is to adapt science and technology progress to the people's needs, avoiding at the same time adverse effects.

Then what should be done to translate this idea into practice? Before everything else, we should establish and maintain the equilibrium of scientific and technological development. It is, however, very difficult to define precisely what a true equilibrium is. But, from the standpoint of one who administers science and technology, it may be defined as restoring the balance between the biological sciences and the physical sciences and engineering, for the former is lagging behind the latter. This is abundantly clear from the fact that, although we have achieved a technology for making and utilizing certain chemical substances, we have as yet not fully understood their impact upon living organisms. This view is further supported by the assertion that the age of the biological sciences is making its advent whereas, in the past, the physical sciences have been playing a leading part in the progress of science.

From such a point of view, we in Japan hope to place special emphasis on the promotion of the "life sciences" as a national project. Of course, we will not do this at the expense of the other sciences. Rather, we will continue to strengthen existing

research organizations, their manpower and current research efforts in those other fields of science.

Promotion of the life sciences is likely to stimulate new technological innovations. Living things are nature's best precision machines. And it is said, for example, that the union of the life sciences with engineering may result in future innovations similar to those which came from the marriage of the physical sciences and engineering after the Second World War, in such areas as atomic energy, electronics and chemical engineering.

These concepts were the basis of the following remarks which I made at my first press conference after taking office as Minister of State for Science and Technology: "It is my desire to promote the development of new technologies and industries by giving priority to such scientific disciplines as the life sciences."

For this purpose, I proposed a study on ways to promote the life sciences at a meeting of the Council for Science and Technology, the highest deliberative body on science policy in Japan. The proposal, supported by the members, is now being considered by the council. At the same time, I have directed that a site for a new research institution devoted to the life sciences be established in Tsukuba New Town for Research and Education, now under development.

It is also important to promote techniques for controlling science and technology. Perhaps such techniques are also a science. In Japan, the term "soft sciences" has been designated for this new area.

In constructing the *Shinkansen* (the new railway trunk line between Tokyo and Osaka) we were able to create a rapid inter-municipal transit system. This project required the development not only of hardware, such as special trains and tracks, but also of software systems, such as new methods of operation and control. As far as cars are concerned, however, our technical efforts have been concentrated on improving the performance of each vehicle, while neglecting to develop the necessary software to insure a well-managed road network. Consequently, we are now plagued with car exhaust, traffic congestion and accidents. Although cars are far more difficult to manage than trains, for the obvious reason that the former may be considered as countless individual elements while the latter is a single component, it cannot be denied that the delay in the development of the necessary software is one of the chief factors responsible for our problem with cars.

It is clear therefore that the development and use of new technologies must be accompanied by the development of methods of control. If circumstances warrant it, it might be necessary to modify a new technology so as to meet the user's total requirements.

Technology assessment is an important part of the soft sciences. In Japan, the Science and Technology Agency (STA) is engaged in developing methodologies and studying ways to apply them to science policy.

To forecast the impact of new technologies on man and society and to develop software systems for utilizing it effectively, it is essential that the studies undertaken should draw on the latest knowledge in psychological, behavioural, information and other sciences.

The relatively slow development of these sciences, which constitute the base for the soft sciences, is as conspicuous as that of the life sciences to which I referred earlier. It is now an urgent task for us to promote these sciences.

In promoting the development of these two fields of

science (the life sciences and the soft sciences) we must seriously reconsider the role of the STA. Broadly speaking, the STA has two chief aims: first, the formulation of national science and technology policy and coordination of policies of the various ministries and agencies concerned; and, second, promotion of "big science", such as atomic energy and space development. As the STA is responsible for the budgets of the space and atomic energy programme, its efforts to secure funds for these national projects are led by the head of the agency himself. This, coupled with public support, has resulted in sharp increases in the budgets for these programmes. As for the other areas of science and technology, administrative responsibilities cut across the various ministries and agencies, and the ministers, already pressed with other tasks, tend to show but little interest in scientific programmes.

Jurisdiction over promotion of life and soft sciences also cuts across ministerial lines, so I intend to take a more active part in studying ways to promote these high disciplines. We consider the life sciences in particular as another area of "big science" following atomic energy, space, and ocean development. The opinion has been expressed that an attempt to increase national expenditure on research and development, with priority given to some special fields, is prejudicial to basic scientific research. One should, however, realize the value of the priority policy, for it has been of great help not only in markedly elevating the level of the fields of science concerned, but also in stimulating the flow of research funds into related fields including basic research. This, coupled with strengthened basic research at universities, would contribute to the elevation of the level of science as a whole.

The Organization and Activities of the Science Council of Japan

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JUST after the Second World War, when the allied forces occupied Japan and were introducing various innovations in order to demilitarize and democratize, the Japanese people began their own moves towards democratic reforms in political, economic, social and cultural circles.

In these circumstances, many scientists and many academic institutions and societies began to criticize and/or self-criticize their behaviour in the context of the war and to introduce fundamental reforms of the existing governmental and semi-governmental institutions concerned with science and technology.

In response to these moves, the Japanese cabinet, led by Mr T. Katayama, established a consultative committee called the Committee for Reformation and Renewal of the Science Research System, which advised the government about future plans for state institutions involved in scientific research. This committee, it should be noted, consisted of members elected by scientists of all disciplines throughout the country.

After energetic deliberations for six months, the committee asked the next cabinet, led by Mr Ashida, to take the necessary steps to inaugurate the Science Council of Japan (JSC).

In July 1948 parliament enacted the Science Council of Japan Act, which was drafted by the administration on the basis of the proposals of the consultative committee. After the first election of members in November of that year, the JSC at last came into being on January 20, 1949.

Unique Character

The JSC is a state body established as "the representative body of the scientists of Japan both in and out of the country" (Article 2 of the Act). As a state body, the JSC is under the jurisdiction of the prime minister and is financed out of the

national budget. The JSC has, however, a unique characteristic which sets it apart from other administrative bodies; unlike the latter the JSC functions independently of the administration, and the members of the JSC are not nominated by the prime minister or any other ministers but elected directly by scientists and are consequently responsible only to the latter (Articles 7 and 17). Hence the JSC is often dubbed "the parliament of scientists", although it is quite different from a legislative body.

The JSC is often taken for a science academy by foreign scientists. However, the JSC is neither a science academy in the usual sense nor a research institute like the Academy of Sciences* of the USSR.

The JSC is primarily a deliberative body which performs neither executive nor research functions as such. But the JSC does carry out some executive work such as holding and/or supporting international scientific conferences in Japan, sending Japanese scientists to international meetings overseas, and participating in the international scientific programme. In addition, the JSC makes recommendations to the Ministry of Education about the membership of the committee responsible for distributing the grants-in-aid of that ministry (a total budget of 10,000 million yen (£14 million) in 1972). It is also responsible for the public lecture on "the freedom of thought and learning", which is given twice a year, but activities such as this are of secondary importance.

The objective of the JSC is "to contribute, by the joint will of the scientists throughout Japan, to peaceful reconstruction of this country, and to the promotion of the welfare of mankind, as well as to the advancement of science in cooperation with academic circles all over the world, being convinced that the science provides the very basis of a cultural nation" (preamble to the JSC Act). And the JSC, in its capacity as the representative body of the scientists of Japan both in and out of the country, "aims to encourage the improvement and development of sciences as well as to reflect scientific attainments on administration, industry and people's lives" (Article 2).

In the fulfilment of these objectives the JSC has two well defined duties—first, to discuss important matters concerning

* The Japan Academy is a completely separate body.

science, and to make efforts to realize the conclusions reached through deliberations; second, to coordinate scientific research (both internally and internationally) and to enhance its efficiency. As was mentioned earlier, the JSC performs these functions independently; in other words, quite free from government interference (Article 3).

The Act also stipulates that although the government may consult the JSC on certain matters concerning science, the JSC is authorized to make recommendations to the government about such matters as ways and means of promoting science and technology, utilization of scientific discoveries, training of scientists and other matters within the realm of the aims of the JSC (Articles 4 and 5). Clearly the JSC is legally empowered to function as a consultative and/or advisory body *vis à vis* the government.

Organization of the JSC

As far as the JSC is concerned, science is interpreted very broadly to include not only natural science, but also the humanities and the social sciences as well. Thus the JSC has seven divisions, namely: literature, philosophy, pedagogy, psychology, sociology, and history; law and political science; economics; pure natural sciences (mathematics, astronomy, physics and so on); technical engineering; agriculture; medicine, dentistry and pharmacology.

The membership of the JSC is fixed at 210, and each division consists of 30 members. The status of members is an honorary (unpaid) one, and the term of office is three years.

The members are elected by the "voters" belonging to each division and any scientist who satisfies certain requirements may be registered as a voter by applying to the Central Returning Committee of the JSC. Election takes place every third year, and the votes are cast by post. The number of the voters is a little less than 180,000. The votes are cast for nominated candidates, division by division. As most candidates are nominated by institutions and societies (the Mathematical Society of Japan, for example), the members of the JSC are usually considered to be representatives of the academic societies in Japan.

The JSC holds a general meeting of the 210 members twice a year. In addition, an extra general meeting is held at the beginning of each term for election of the president and two vice-presidents. At the same time each division elects four officers—a chairman, a vice-chairman and two secretaries.

Thirty-one members—the president, vice-presidents and division officers—constitute the Steering Committee, which usually meets once a month to implement the decisions of the general meeting and to conduct routine business.

The secretariat consists of a secretary-general and a permanent staff of eighty who are government officials belonging to the prime minister's office.

The JSC has three categories of committees to fulfil its basic functions. First, there are six standing committees, each consisting of fourteen JSC members, two from each division. These are the committees concerned with research funds, organization of science, long-range research projects, international scientific exchange, freedom of thought and learning, and status and condition of scientists.

Second, there are eleven special (*ad hoc*) committees, each consisting of about twenty members, who need not be members of the JSC. The special committees are set up either to deal with matters considered to be urgent for the JSC's task or to cooperate with important international research programmes like the International Biological Programme (IBP). The special committees on environmental problems, on the atomic energy problem, on the problem of urbanization, on Okinawa, on humanity *versus* science, on industry and people's lives, and on university reform were set up at the start of the present (ninth) term. There are also special committees on the IBP, the International Hydrological Decade, International Geophysical Observation, and Antarctic Research.

Third, there are fifty-eight permanent research liaison committees, whose tasks are to act as the national committees to the respective international unions (for example, IUPAP), to coordinate the activities of the Japanese scientific and academic societies, and to examine future plans for certain specialized fields of science. Between ten and forty of the members of these committees are put forward by the respective academic societies and work side by side with the relatively smaller number of JSC members. The total number of members is 1,250.

Thus the JSC is run not by the 210 council members but by the concerted efforts of more than 1,500 scientists.

Besides the three categories of committees described above, there are the organizing committees, ten in all, for the preparation and organization of international conferences sponsored by the JSC, and the returning committee which deals with the election of the JSC members and the registration of the "voter-scientists".

Principal Activities of the JSC

Since the inauguration of the JSC about 400 recommendations and proposals have been submitted to the government. Of its activities and achievements one might mention its contributions on the problems on the effects and uses of radioactive substances and on atomic energy; these are still considered to be important. One of the recent activities is a discussion about science and technology in the last quarter of the twentieth century. I shall discuss the long-range science programme, including the establishment of institutions, later in this article.

A special committee on the effect of radioactivity was set up immediately after the first test in March 1954 to coordinate scientific research on injuries and other effects caused by the series of nuclear explosions conducted by the United States on Bikini Atoll in the South Pacific Ocean. Because of the efforts of the committee, which included the sponsorship of a joint Japanese-American meeting on the effects and uses of radioactive substances in Tokyo in November 1954, the serious contamination caused by radioactive substances was made clear, on the basis of the radioactive survey carried out in the South Pacific Ocean by the exploration vessel *Shunkotsu-maru* of the Fishery Agency of the Japanese government. The results were published¹, and unexpectedly serious pollution of the atmosphere, rain water, sea water, fishes and other marine animals and plants was reported—including the after effects of the atom bombs dropped on Hiroshima and Nagasaki.

The special committee for atomic energy was set up in 1965 to discuss future plans for research into and utilization of atomic energy in Japan. In 1954, the JSC came out with the statement that the research and utilization of atomic energy should be conducted according to three principles—autonomy, democracy and public accountability*. The three principles were proposed to the government, and were duly embodied in the Basic Law of Atomic Energy (Article 2). It still has a very important bearing on the atomic energy policy of the Japanese government, for secret research especially on nuclear weapons is prohibited under it.

The JSC started discussions on the problems of science and technology in and after the 1970s on the basis of the resolution of the general meeting in October 1970, and six months later passed a resolution calling for a comprehensive and fundamental examination of the problems facing science and technology in and after the 1970s. The subcommittee attached to the steering committee then began to organize the working groups, which met many times to discuss their respective problems. The committee elaborated the original report and this was published in 1972².

Nineteen problems were earmarked, and they can be classified as follows—first, problems of all kinds concerned with the very

* The implications of the three principles are autonomous development in research and utilization, to be based on the scientists' initiative and open to public scrutiny.

basis of science and technology; second, important social and economic problems that require a scientific and technical approach for their solution; and third, practical problems concerning the administration and management of scientific and technical researches that are in need of immediate solution.

The JSC started its ninth term in January 1972 with the aim of deepening and developing the contents of the above report, and has set up the special (*ad hoc*) committees to examine the basic problems.

Long Term Plans

Recommendations for the establishment of new institutions for basic sciences are made on the basis of the long term research plan for science in Japan³. This plan has been under discussion since the setting up of the Committee on Long Term Research Projects in 1954.

In that year the committee presented the draft resolution on "five principles for promoting scientific research": the resolution is as follows:

(1) To enhance the status of the universities and colleges, in particular by improving on the present inadequate, irrational and non-flexible budget.

(2) To promote the establishment of institutes of a new type, not confined to a single university or college but available for inter-university use.

(3) To establish a system of visiting professors, and to relieve the rigidity of the staff system and the traditional autonomy of the universities.

(4) To assist the JSC in drawing up a long term research plan.

(5) To make government statistics more easily accessible to university and non-government scientists.

The government accepted and acted on some of the recommendations, for example, the one concerned with visiting professorships, but did not make as much effort along the lines of the other principles. As for the long range research plan, the government gave very little help to the JSC, but the JSC nevertheless undertook to soldier on with the research plan—the fourth item listed above—without much help of the government. The scientists affiliated to the JSC made considerable sacrifices, in terms both of their own money and time, to draw up the plan. About a thousand scientists were directly involved.

Meanwhile in October 1965 the first five year plan presented by the Long-Range Research Project Committee was accepted by the general meeting, and was communicated to the government as a recommendation.

Table 1 Summary of the Five Year Plan

Items	Budget (yen)	
	Original (1971) millions	Revised (1977) millions
I (a) Running expenses for universities, colleges and affiliated institutes	204,000	330,000
(b) Running expenses for national institutes	58,000	100,000
II (a) Projects	20,000	30,000
(b) Establishment of institutes		
(c) "Big sciences"		
III Computers, libraries and so on	10,000	10,000
IV Scientific information system		
V Science foundation	30,000	50,000
Total	342,000	560,000

The actual science budget was 120,000 million yen in 1965. The figures are summaries of a great many data and much background material.

Most of the budget for the project to build a practical reactor is excluded for 1977, but is included for 1971.

Table 2 Institutes Established According to JSC Recommendations since 1953

Institutes	Host universities	Established in	Recommended in
Nuclear study	University of Tokyo	1955	1953
Solid state physics	University of Tokyo	1957	1956
Protein research	Osaka University	1958	1956
Ocean research	University of Tokyo	1962	1958
Mathematical sciences	Kyoto University	1963	1958
Plasma physics	Nagoya University	1961	1959
Language and cultures of Asia and Africa	Tokyo University of Foreign Studies	1964	1961
Research reactor	Kyoto University	1963	1962
Space and aeronautical science	University of Tokyo	1964	1962
High energy physics	(Ministry of Education)	1971	1962
Nuclear physics	Osaka University	1971	1962
Primate research	Kyoto University	1967	1964
Welding	Osaka University	1972	1964

The plan is summarized in Table 1, in which the figures show the budget for the last year of the five year period, that is to say 1971. The plan was revised in 1971 and figures for 1977 are also shown. These figures show the scale of present and proposed government expenditure on research. The total amount is approximately 10 per cent of the national budget in 1965. The figures include salaries of the staff and employees of the institutions.

The figure in item II (b) of Table 1 gives the amount earmarked for the establishment of new institutes. Recommendations have been made such that the total expenditure for the establishment of new institutes, including those recommended previously, does not exceed that given in Table 1, except for the cases of "big science" such as high energy physics.

The names of the institutes established according to the recommendations of the JSC are listed in Table 2, while those that were recommended but have not yet been established are shown in Table 3.

It was also recommended in 1963 that large computer centres for use by many universities should be set up, and seven inter-university computer centres were duly completed in 1970.

One may ask why some of the recommendations for new institutes have been shelved for such long periods of time. This is also a serious problem for Japanese scientists, and to understand it it is important to know how recommendations are dealt with by the government. The JSC's recommendations are delivered through the Council of Science and Technology, which has a liaison section for the government and the JSC. The members of the council are the prime minister (chairman), four other ministers directly concerned, the president of the JSC and five members appointed by the prime minister. The council does not approve or reject recommendations of the JSC, but only decides which ministries should deal with them. The recommendations which have not yet been acted on are,

Table 3 The Twenty-three Institutes Recommended by the JSC but not yet Established

Recommended	Institutes
1965	Ethnological study (museum)*, molecular science*, atmospheric physics, earth science, information engineering, information sciences
1966	Biology*, palaeontology
1967	Crystallography, comprehensive regional geography, human behaviour, breeding sciences, basic physiology
1968	Environmental radioactivity, radiation effects, fundamental organic chemistry, biophysics, structural engineering
1971	Water resource, biologically active natural products, complex chemistry, quaternary, composite materials

* The establishment of these institutes has been agreed by the Ministry of Education.

however, formally either under examination or to be considered by the government. Nobody knows when a decision will be made about them.

The total sum needed to establish the institutes listed in Table III is certainly less than 40,000 million yen. As the time from the commencement to the completion of an institute is never less than four years, the annual expenditure never exceeds 10,000 million yen, the figure in item II (b) of Table 1, even in the unlikely situation that all the listed institutes come to fruition on the scale envisaged.

At the same time the institutes listed in Table 3 are the necessary minimum for the coherent development of science

and technology in Japan. If one recalls that the gross national product and the national budget were 72,440,000 million yen and 7,950,000 million yen, respectively, in 1970, it is clear that the JSC has not recommended too many institutes but that national investment on basic science is too small.

¹ *Committee for Compilation of Report on Research in Effects of Radioactivity: Research on the Effects and Influences of the Nuclear Explosions at Bikini* (Japan Association for Promotion of Science, 1956).

² *The JSC: Science and Technology in and after the Seventies* (Printing Bureau, Ministry of Finance, Tokyo, 1972) (in Japanese).

³ Fukushima, Y., *New Scientist*, 27, 178 (1966).

An Exile's View of the Contemporary Scene

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The views of Dr Sibatani, a scientist who left Japan six years ago, must of necessity be impressionistic and suffer from inaccuracy. But he is not bound by emotional involvements, personal considerations or official responsibility.

SCIENCE in Japan today is faced with three problems that interact one with another and demand urgent solutions:—First, there is an incompatibility between the traditional code of values and the principles of science originally introduced from the West. Second, there is a significant disparity between domestic science and technology, the latter of which has so far been seeking quick beneficial effects. Third, the basic philosophy of science needs reappraisal in the context of the putative new and more humane code of values.

Rise and Decline

In my work on nucleic acid research, which later became molecular biology, I have experienced facets of each of these problems. First of all, the Japanese university system is suited to developments on a relatively small scale; these are often meticulous refinements, viable for rather short periods, of developments that were probably "selected" because they were more easily grasped by those who tried to transplant science from abroad. The production of centres of excellence, lasting a few generations say, is harder to emulate, and any possible scheme may turn out to conflict with the existing framework of non-European institutions. Any plausible scheme would have to be based on the indigenous culture of the society, and Japan, like any other nation state, must find its own solution.

For the short term development of excellence, Japan has already established its own system, which may work provided half or fully established fields of science are continuously introduced and elaborated on. But the system is liable to counteract efforts to open up a novel field of scientific enquiry. One aspect of the system is the so-called *kozasei* in the university, that is an extreme formalism of uniform and "egalitarian" allotment of limited resources to each small unit of research and education headed by a professor, and the very high tendency of students and academic staff to inbreed in universities, especially the old and prestigious ones. This formalism encourages a diffusion of responsibility, which is essentially what is practised in the name of autonomy and democracy in Japanese universities.

The *kozasei* often gives each professor absolute power over a small number of people. It may render some professors immune to review by peers and thus it undermines the traditional mechanism of maintaining high scholarly and moral standards among scientists—the concept of external examiners is unknown in Japanese universities for example. Given a social institution which strongly favours a life-long commitment to a particular job, the breaking of a relationship between a student and the professor he or she has chosen to work under could therefore ruin his or her academic career. Obviously, such a system puts those who work in a new field like molecular biology in a difficult position. At first, the tendency of physical and biological sciences to merge together seemed to shatter those "old" institutions. But the advance of the first generation molecular biologists to professorial rank, which took place concomitantly with the maturation of the discipline into its "academic period"¹, produced the situation in Japan where the leading molecular biologists began to find vested interests in the *kozasei*. Until the late 1960s most of the molecular biologists could find jobs only in research institutes, and were excluded from full participation in undergraduate and graduate education. This might explain why, Japan has produced a handful of good molecular biologists working on prokaryotes but has so far failed to produce eminent Japanese workers on eukaryote molecular biology. There is some evidence to show that young scientists in molecular biology are as frustrated now as were the then rising molecular biologists when they started their work in various corners of the older style departments during the 1950s. And the eminence or popularity of molecular biology in Japan may now simply be counteracting the development of newer fields which may even employ the techniques of molecular biology. Certainly that was not the thing people were aiming for when they envisaged the possibility of radically changing the academic structure using molecular biology as a lever.

Turmoil and Suppression

Most Japanese scientists have always felt half starved economically. The "bad" old days of reconstruction after the Second World War are still in living memory. The gradual recovery of the economy and the latest outburst of expansionism has at least removed hardship for scientists of higher ranks, but the shortage of research jobs and funds, housing, income and social welfare facilities, especially for young scientists, has continued to be a problem. Rank and file scientists are usually paid considerably less than their contemporaries in business or industry, and government expenditure on scientific research and education has never been over-generous because of the

policy of national dependence on imported technology. The recent employment problems of scientists in the United States and Britain is somewhat reminiscent of the now chronic Japanese situation. Under these circumstances Japanese scientists strive for competition and for an international recognition by peers at the "source" of Western science.

When the extensive campus confrontation erupted in 1968, most of the eminent scientists had just emerged from a long tough period. They may have anticipated a degree of improvement because of the nation's quickly rising economy. So the student revolt, quite understandably, was nothing but a nuisance to them. It was reported that the dedicated and competent scientists still active at the bench were the most uncompromising and oppressive to the students. It is true that many of them enjoyed a high international reputation, but, protected under the *kozasei*, they could well be powerful scientific entrepreneurs². And to those who aspired to such a high prestige, the way seemed wide open for a headlong plunge into the corruption of science².

Here I shall touch on the third point mentioned at the beginning of this article. From what I have already said it is clear that students and junior staff in Japanese universities are underprivileged in a number of ways and have due cause for grievance. As the campus turmoil went on, however, some of them became gradually aware of the deeper roots of the trouble, namely the dehumanizing and alienating trends of a quickly expanding economy that is obviously linked to, among other things, industrial pollution and the Vietnam War. They also became aware that, by seeking more privilege in their own prestigious universities, they were actually seeking easier ways of effecting their own integration into the ruling class. Thus, in spite of their desire to identify themselves with the underprivileged of the world at large, they started wondering whether, by campus protest for more efficient and fair education and administration, they were dissociating themselves from most of their fellow human beings to join the established few. Thus, the chief outcome of campus unrest, although often grotesquely marred and obscured by ugly violent scenes, was to highlight the urgent need for very deep analysis, at various levels of radical ideology, of the assumptions upon which university research and education had been based^{3,4}.

But this was not only inconvenient to most of the leading scientists but also to the Japanese government, desperate to keep up the predetermined course of economic expansion. In the atmosphere of intimidation that was generated in no time at all by the government threats were made to close the universities in times of trouble and to redeploy their staff under "certain" conditions only, and all the basic questions then being asked were shelved. The turn of events that followed was all too anti-intellectual and anti-social⁵. Indeed, when the dust had settled, it turned out that the old university institution had emerged unscathed.

The response by leading scientists in Japan to student protest was evidently far more negative than that of their American counterparts. This may be partly because at that time the trauma of the Vietnam War must have been more painfully felt in the USA, but also because American scientists are at the top of the international scientific community, a position which leading Japanese scientists were desperately striving for. So it was admittedly more frustrating for the Japanese scientists to readjust themselves to a new goal. But, after all that has gone on, science in Japan still relies on borrowed plumes and the scientists still tend to stop short of asking more fundamental (= radical) questions.

Scientific Journalism

It is impossible not to neglect the regrettable absence of an adequate forum for the exchange of views and criticisms that is available to the whole community of scientists and academics in Japan. There is, of course, the "democratically elected" Japan Science Council (JSC), but it functions as an advisory

body to the government and is not open to uninhibited participation by rank and file scientists. Japan does not have its counterpart of BAAS, AAAS or ANZAAS. Nor does it have scientific journals functioning like *Nature*, *Science* or *Search*, which not only publish scientific articles but also take up issues arising at the interface between science and society and provide a wide arena for constructive debate. Scientific journalism in Japan faces several difficulties. First, leading scientists are much less socially and politically conscious than those, say, in the USA, although a much larger proportion of young scientists may be at least at some stage interested in leftist ideologies. Second, academic and other appointments of scientists are mostly made by personal arrangements, and the public advertising of vacant positions is not the accepted way of going about things. Third, papers written in Japanese are of little use for winning international prestige, whereas socio-scientific debates must be carried out in Japanese, so it is difficult to combine the two functions in one journal. Fourth, critical accounts of domestic occurrences relevant to science and society that appear in a commercially based scientific magazine may hurt certain sectors of the scientific community, and may cause the magazine to lose readers and authors. Perhaps these are the reasons why, in spite of the presence of a huge potential circulation, a weekly intellectual socio-scientific magazine addressed to professional scientists cannot evolve in Japan. Meanwhile, the emergence of a unified national association of scientists may not be called for in the presence of the JSC.

News on events in Japan relevant to science can evidently not easily be obtained through scientific journalism. News available from other sources lacks systematic coverage and/or suffers from poor circulation. Editorials that sought to discuss such subjects critically were once published by *Shizen*, a Japanese monthly counterpart of *New Scientist*, but did not survive more than a year. This lack of a common forum for discussion of the Japanese domestic scene and its implications for the world at large is probably responsible for the apathy of a mass of indifferent, naive or helpless scientists faced with apparently intractable social problems of mounting acuteness brought about by science and technology.

I should point out that this deficiency may have rather grave consequences now that the Japanese economy, based on the progress of science and technology, has reached a stage at which it can seriously affect the resources and people of other parts of the world, especially the underdeveloped countries. The otherwise mostly admirably written report on the national science policy by the JSC⁶ has completely missed this point.

Whither the Universities?

There is very little written about what universities in Japan are like these days. Perhaps it is not pertinent to talk about it, let alone to analyse it systematically. The trauma inflicted during the past few years has been so deep that all the parties involved are sensitive to any discussion of the subject. According to fragmentary information I receive from various sources, students still work hard enough to get good marks, but at the same time are quite nihilistic and shrug off any suggestions by the faculty that discussion about the reform of the university should be reopened. Moreover, the resistance by the radicals has not entirely ceased. Parts of the University of Tokyo and Kyoto University are still under occupation by students or junior staff. But they leave the teaching machinery alone so that the formal progress of students through the university is no longer affected. The police force, once helpful in suppressing the revolts, cannot easily be stirred up; now they just sneer at the incompetence of the universities to exercise control over such disturbances.

The universities are apparently peaceful, but are not operating normally. One is not supposed to acknowledge this publicly, just as one was not supposed to acknowledge that the "divine" Emperor was just an ordinary human being, even in the univer-

sities, until the end of the Pacific War. The atmosphere of suppressed hostility in the university is so unbearable, however, that some of the professors wish they could leave. But usually there is no place to go. Meanwhile, the academic-industrial complex is even being reinforced. A new national university (quite a rarity in Japan) is going to be opened in the new town of Tsukuba—about 70 km from Tokyo—which is also to incorporate an assembly of government scientific institutes. Each department of the university is to be established with a strong tie with a particular industry.

Although documents about abortive plans for reform are being amassed in universities, the whole system apparently does not know how to start changing itself. The government makes the best use of this period of silence and apathy to tighten its direct bureaucratic grip on the once "autonomous" universities, because there can be no organized resistance from the faculty. In the commercial publications on the other hand there is an outcry for the restoration of human values and a habitable environment (people die of pollution in Japan); I have not, however, heard of any plan in Japanese universities to open new interdisciplinary courses on the broad aspects of, say, environmental issues or studies of man. Quite a few experimental courses along these lines, in the context of university reform, are under way or due shortly in some other countries. The Zoological Society of Japan has recently called an attempt to organize a symposium on environmental pollution within its organization a "degradation of the society", while the deaths of wild birds in certain rural areas are becoming alarmingly prevalent. I fear that these symptoms are a good

feeding ground for another political runaway into the dark ages.

There is, however, a burgeoning of new trends. Two radical scientists in the Medical and Engineering Schools of the University of Tokyo, K. Takahashi⁷ and J. Ui⁸ have, on the basis of their own personal research, independently and successfully organized meetings or courses on the campus which are attended by concerned citizens and patients. Their activities may indicate the way in which the service of scientists to society should be channelled, and are quite a departure from the paradigm within which the nineteenth century-style activities of academics find their own expression and identity.

¹ Stent, G. S., *The Coming of the Golden Age* (The Natural History Press, Garden City, New York, 1969).

² Ravetz, J. R., *Scientific Knowledge and its Social Problems* (Clarendon Press, Oxford, 1971).

³ Takizawa, K., *Ningen no "Genten" towa Nani ka? (What is the "Original Point" of Human Beings?)*, in Japanese (San'ichi-Shobō, Tokyo, 1970).

⁴ Tōdai-Funsō-Bunsho-Kenyūkai, *Tōdai-Funsō no Kiroku (Records of the Campus Confrontation at the University of Tokyo)*, in Japanese (Nippon-Hyōron-Sha, Tokyo, 1969).

⁵ Orihara, H., *Daigaku no Taihai no Fuchi nite (By the Abyss of Academic Decays)*, in Japanese (Chikuma-Shobō, Tokyo, 1969).

⁶ Japan Science Council, 1970-*Nendai-Ikō no Kagaku-Gijutsu ni Tsuite (On Science and Technology during the Seventies and Thereafter)*, in Japanese (Ministry of Treasury Printing Office, Tokyo, 1971).

⁷ Takahashi, K., *Chūō-Koron*, 152, in Japanese (August 1971).

⁸ Ui, J., *Kōgai-Genron (Fundamental Aspects of Industrial Pollution)*, 1-3, in Japanese (Aki-Shobō, Tokyo, 1971).

Unrest in the Japanese Universities

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Professor Katsunuma summarizes the causes and results of the recent student troubles at Tokyo University.

I SHOULD begin by issuing a warning that this account of the disputes in Japanese universities may be introductory and un-specific, and that as dean of the medical faculty I was in the thick of the dispute at Tokyo so my view of it is likely to be subjective.

After the Second World War the Fundamental Education Law was enacted under the new constitution. Accordingly, Japanese universities, which had been established since the Meiji period, changed their forms so as to contribute more effectively to education, research, and society, while maintaining their historical traditions.

During this time the numbers and types of university—national, public (prefectural or metropolitan) and private—all increased. By 1971 there were 76 national, 33 public, and 291 private universities. The administration of Japanese universities is in effect undertaken by the Ministry of Education, which guides and supervises teaching and research both directly and indirectly. Various departments and faculties also come under the influence of appropriate government agencies and other bodies, so departments of law are influenced by the judiciary, departments of economics, by the commercial world and by those government agencies with economic associations, and medical faculties by the Ministry of Public Health.

It needs to be remembered that Japanese universities have only short histories compared with universities in other culturally advanced countries. Even the oldest foundation, the

University of Tokyo, is only about a hundred and ten years old. Even so, the concept of university autonomy, the idea that a university of whatever type should conduct its own affairs, has been acknowledged throughout this short period as a fundamental tenet.

The physical sciences have recently made progress so remarkable that it can be considered a technological revolution. The scope and depth of the biological sciences have increased, and information science, made possible by the development of computers, has come to the fore. And new political and social ideas and values have proliferated. These developments, which have taken place at breakneck speed, have made questions of how to organize and run universities very important.

Most people would recognize that undergraduates, graduates, and others of the younger generation in every age and country have been relatively idealistic and sometimes inclined to seek very rapid change. At almost the same time that disputes were taking place at Columbia University and at the Sorbonne in Paris, there was an outburst of dissension among the students of the medical faculty of Tokyo University. One of the students' chief aims was to improve medical education, and, particularly, to reorganize the "intern" system. The issue that gave rise to the dispute was perhaps unusual by world standards; its course was most similar to that of the dispute at the London School of Economics.

There were three groups of students. Some wanted reform; some, the conservatives, favoured the continuation of existing institutions; and some, though interested in the problem, did not want to get involved. The faction in favour of reform was further split into those who advocated very extreme forms of violence, and those who were somewhat critical of violence. The dispute spread to involve students outside the medical

faculty and to embrace new issues, such as the uncertainty felt by students about their prospects after qualifying. In the course of the dispute student factions vigorously opposed each other; the administration suspended the awarding of grades and closed the laboratories for several months. The president of the university, the deans, board chairmen, and other officials negotiated with the students in several ways—and exchanges between them were sometimes violent. Sometimes, also, events reflected the influence of international conditions and internal Japanese politics.

At one point matters reached the state where a minimum of order in the university was only preserved by the intervention of the police. But as a result of the dialogue between students and university authorities, and with help of various kinds from the community as a whole, the dispute was gradually damped down. I myself held to the principle, as a basis for the solution of the problem, that “as the university is a social group which aims first and foremost at the pursuit of education and research, the situation in which tomorrow and the day after tomorrow can actually be scheduled is indispensable”. The efforts

towards a solution, which were inspired by this principle, played, I believe, a significant part in facilitating a return to normal teaching and research.

One could summarize the changes that came about through the dispute as: first, progress towards university reform; second, increased student participation; third, an increased flexibility in the curriculum; fourth, greater recognition of universities among people outside; fifth, more expenditure on teaching and research; sixth, a movement to establish new universities; seventh, a greater respect for regional differences and, at the same time, a greater emphasis on international relations; and eighth, greater awareness of social needs. At present these points are being keenly debated and put into practice at all the universities.

National and international conditions being what they are, universities in the “information society” find themselves in a very complicated position. I should like to think of the future of Japanese universities as based on the principle, enunciated previously, of the university as a society seeking, first and foremost, after education and research.

Scientific Research in the Universities

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Professor Kakiuchi surveys the state of research in the universities—both national and private—and pinpoints the improvements that could be made.

ANY discussion about science and technology in Japan must include some mention of the role of the university in the past, for the first policy of the Meiji government (1868–1912) was to establish the National University, Tokyo University, as a means of educating higher government officials and engineers. These groups were supposed to be the lynchpin in the process of modernization of the administration and economy of the country.

Scientists and engineers from Britain and the United States, and medical doctors from Germany, had been teaching in the university, but they were soon replaced by young Japanese who had studied in western universities. The western tradition was transplanted into the academic community by both foreigners and by Japanese returning from abroad, and this made a great impact on the future development of Japanese science. University professors had frequent opportunities for studying abroad in those days, with full support from the government.

Although the situation has changed greatly over the years, especially since the Second World War, the national universities still retain their prestige and advantageous positions, and the mainstream of science and technology continues to be dominated by them; in the field of medicine, however, the private universities now make considerable contributions. In view of the historical background, it would be better to start with a description of the national universities, although the functions of the private universities should not in the slightest way be neglected.

Research in Science and Engineering

One of the characteristics of the national universities as institutions for education and research is the *Koza* system, associated with the professorial chairs. For the faculties of science and engineering, to which a graduate course is affiliated, a *Koza* consists of a professor and an associate professor together with two assistants and a technical staff of two, all of whom are government employees. The individual *Koza* is supposed to be responsible for research and education in topics like nuclear physics, biochemistry, medical electronics and so on. The *Koza* system is, however, not applicable to the faculties in universities created since the Second World War, and to which no graduate course is affiliated. Money for the appropriate research and educational activities is allocated to each *Koza*, the average amount being several thousand pounds a *Koza* a year for science and engineering. This kind of personnel and expenditure “package” plays an important part in developing the activity for which the individual *Koza* is responsible, but, on the other hand, it has the drawback of tending to keep the *Kozas* separate, thus allowing less collaboration and sharing of facilities than might otherwise be the case.

The rapid growth of science enormously increased the demand for manpower and money for research, and the increase in the numbers of science and engineering students, chiefly caused by the population peak and the industrial manpower policy, of itself necessitated a corresponding growth in the size of the faculty. The number of students has, however, already reached its maximum, so no further increases in staff and expenditure would be expected. Not only, however, is there an increasing demand for facilities as the result of rapid development of experimental techniques, but even worse, most of the facilities soon become outmoded. When a new *Koza* is established, the initial funding for the facilities (about £10,000 a *Koza*) is provided by the govern-

ment, but there is no machinery for providing extra money afterwards to keep the facilities up to date. This is particularly serious when a new faculty member is appointed to the chair of an existing *Koza*. No particular consideration would be given to the need for new facilities and equipment, and the only money available to the new man is the standard amount allocated for the running expenses of his *Koza*.

It is clearly desirable to look with special favour on any research project proposed by a newly appointed member of the faculty, which would, of course, have to be examined and evaluated in an appropriate way. In the larger faculties, it is fairly easy to earmark a certain portion of the running expenses for such innovative purposes, but in most cases this course of action is practically impossible because of the size of the budget. The situation is much more favourable in industrial research organizations, in other government research institutes under various ministries or the Science and Technology Agency, and in some others, such as the Railway Technical Research Institute or the Electrical Communication Laboratory, which belong to semi-governmental or public corporations.

Research Institutes

Several research institutes affiliated to the University of Tokyo have been established in the past, and many of them—the Earthquake Research Institute and the Institute of Infectious Disease for example—were originally intended to meet the more or less specific requirements of the governments. Although the objectives of these institutes are strongly orientated to the search for means of preventing disasters caused by earthquakes or epidemics, the research is done entirely on an academic basis and does not aim to solve mere technical problems.

The research institutes were not originally intended to be an integral part of a particular university in the sense that the faculties are, but to be affiliated to a university, chiefly for technical reasons. It was considered, for example, to be a practical proposition for a certain university to look after personnel matters, experimental facilities and financial affairs for a particular institute. The research activity itself should, however, be open to scientists outside the university who are working in similar or related fields.

These ideals have been considerably blunted as time passed, and institutes have strengthened their ties with the universities. Most of the research institutes set up before the Second World War are associated with a specific field more or less related to technical or medical applications as described. But after the Second World War the Japanese Science Council thought itself responsible for the promotion of fundamental research, and recommended the government to establish research institutes for theoretical physics, nuclear physics, solid state physics, protein chemistry, marine science and so on. All of these fall under the category of the so-called “research institute for joint use,”^{2,3} which particularly emphasizes its availability to scientists outside the university to which it is affiliated, with the object of encouraging communication and cooperation among scientists. These principles should definitely be applied to all these institutes, but in practice what has materialized is the “special expenditure for the operation of the facilities for joint use” that is paid to institutes of this type. These institutes have made a great impact on fundamental research in Japan. But although relatively well equipped at the time of their establishment, they unfortunately fare no better afterwards than the ordinary faculty with regard to running costs and the problem of keeping their research facilities up to date.

Each of these institutes for joint use has its own specialist field and appropriate research scientists, but there are in general few interactions between the researchers in different institutes. Interdisciplinary cooperation does, however, sometimes occur. For example, there has long been

a positive interest among Japanese scientists in the development of optical studies using radiation from an electron synchrotron. Professor Takashi Sagawa, of Tohoku University, made valuable contributions in the very early stages of the development of this new field of research, using the synchrotron at the Institute for Nuclear Studies. Enthusiastic efforts on the part of the spectroscopists there has led to the instalment of a storage ring to be used in this kind of research, and quite recently the Institute for Solid State Physics began to collaborate closely with the Institute for Nuclear Studies in promoting this kind of research. The rôle taken by the Solid State Physics Subcommittee of the Physics Division of the Japanese Science Council has been very important in encouraging this cooperative venture.

Grants-in-aid for Scientific Research

Apart from the direct funding of research on an institutional basis, the grants-in-aid for scientific research is distributed by the Ministry of Education to an individual scientist or to a group of scientists, on application, for research on specific items. The distribution of the grant seems to be too diversified among various subjects, and no special emphasis has been laid on any particular field(s) of research. As a remedy for this, a special grant for several selected fields was established fairly recently, and this has been of great help in encouraging fundamental research in science. The assessment as well as the evaluation of this special grant and the implications for further funding still, however, remain to be investigated. The total grant for 1972 is roughly £13 million, and the average for each research project supported is £200.

Shortage of Manpower

As the nature of scientific work changes, so the need for scientific manpower increases enormously, and in most cases the traditionally structured *Koza* can no longer function as a convenient unit for research in science and engineering. Operators can now be allocated to the larger instruments, but the supply of technicians who can cooperate closely with research scientists is far short of demand.

One of the problems inherent in present government policy in this respect is, on the one hand, the strict control over the total number of government employees, and, on the other, the relatively low salary scale for operators—a consequence of the lack of appreciation of technicians among the government hierarchy. These difficulties will endanger research in the university, unless appropriate steps are taken. It may not of course be wise simply to increase scientific manpower, but each university should have its own specialties laid down and should concentrate all its resources on selected subjects. It is, however, absolutely true that the present structure of human resources in the university is not continually adapted to the changing situation in science and technology. In spite of the fact that the graduate students, especially on PhD courses, contribute much to the research activities of the university, it must be emphasized that increasing the number of the graduate students is not the solution to the difficulties mentioned previously. An increase in the number of salaried research staff such as research associates or postdoctoral fellows, and the flexible use of such manpower, would be far more reasonable than to rely on a small number of assistants and on graduate students.

Challenges of New Possibilities

Fundamental research in the university is thus confronted with great financial difficulties. Although the *Koza* system and the associated standard funding of each *Koza* is quite useful in ensuring the freedom of individual faculty members from outside interference, there could be a drawback in allocating funds to individual *Koza*. It was, of course, not originally intended that the money available should be

distributed literally equally, but if it is agreed that the standard is rather a nominal one and is only a means of working out the total expenditure of a faculty as has often been emphasized, the original intention of securing freedom of research might lose its meaning. Therefore, a certain minimum amount of money must still be shared out on an equal basis. Taking that for granted, it should also be recognized that the increasing rate of development of instruments and apparatus results in enormous rises in the overall costs, so a single *Koza* can hardly afford them. With improved techniques most of the instruments are becoming foolproof, and this has made it possible for faculty members to share instruments, rather than to monopolize them, and this is certainly reasonable insofar as the necessary operators are available. This justifies the new category for financing group research on a specified subject, which might well be called "special expenditure for research" and which has hitherto been allocated to research institutes but not to the faculty.

Ideally scientists starting on a new problem should be able to carry out pilot experiments and the like, before drawing up plans for the entire project, but the present level of expenditure is far too low to allow this, and is only just sufficient to sustain routine research using conventional apparatus. At least twice as much money as is now available would be necessary to encourage such preliminary investigations. The lack of appreciation of this point is one of the chief stumbling blocks for the present mechanism of financing research in the university.

This problem cannot be resolved merely by changing the rules, but only by profound social appreciation of the very nature of inventive research, for which the university is really responsible.

Role of the Graduate School

There seems at present to be a tremendous confusion in contemporary society about the purpose of a graduate school⁴. Before the Second World War, the graduate school was the place for training research scientists, but since that time the growing demand from industry for graduates of the master's course in engineering has been increasingly evident. This is almost certainly due to an appreciation within industry of the significance of advanced technology, and there is no doubt that it is desirable for the masters to work in industry. The problem is, however, that public opinion increasingly favours the view that the master's course should be the natural extension of the undergraduate course, in fields such as engineering, where there remain so many things to be learnt which cannot be covered in four years.

This situation often leads to the idea of two entirely different graduate courses having different objectives, one is the master's course for training professional specialists, and the other is the doctoral course for research scientists. Taking it for granted that the school for training professionals is necessary, this is entirely different from the idea of the existing master's course, which has been defined as the one for training scientists who are capable of conducting research. Such a professional course would certainly be of value in the field where the degree is required, but there is considerable doubt whether it is as relevant to engineering as it is often supposed to be. What industry really needs, according to certain members of the top managements, is no longer the scientist or engineer who simply accumulates as much knowledge as possible in an encyclopaedic manner, but the person who is really able to contribute to research and development. Therefore, it is more reasonable not to discriminate sharply between master's and doctor's courses insofar as both are intended to develop the student's exploring mind and his ability to conduct research. As for the doctor's course, there is no difference of opinion about its objective, but there are difficulties because the facilities and

equipment available are inadequate.

Another serious problem is the oversupply of PhDs by comparison with the positions available in academic communities. One of the reasons for this is the fall in the rate of increases of positions available in the university. The demand for PhDs from industry is also decreasing, because most companies are at present confronted with difficulties in adjusting themselves to changing economical and industrial situations, and have no definite plans for investing in new fields of research as yet.

Application of Fundamental Research

The industrial application of fundamental research is probably one of the most important and interesting subjects that I shall mention in this article. Obviously, the university is not an appropriate place for development to be carried out, but it should still play an important role of giving a stimulus to and cooperating with research groups in industry. In certain industries, where the domestic standard is still much lower than that of foreign technology, the implantation of overseas technical know-how is far more effective than attempts to develop a purely domestic capability. As soon as the level of domestic technology reaches the international standard, however, the need for research to be associated with it will increase and the tendency to establish new kinds of institution for research within industry will become more and more prominent. Much research is now being done in Japan in just this kind of institute. If the universities were to maintain their role as centres for research, there could be a good opportunity for them to participate in the development and application of research in cooperation with those in industry. There might of course be some inhibiting factors on the side of the university — the financial difficulties in sustaining research, on the one hand, and the inclination of university scientists towards fundamental rather than applied research on the other. Both these problems can only be overcome with difficulty. There are, however, examples of successful cooperation, and the ones now described do not, of course, constitute an exhaustive list. There are obviously equivalent cases in other fields of research.

Sodium glutamate, the well known chemical widely used in the kitchen, was identified in seaweed by Professor Kikunae Ikeda at the beginning of this century as an extract and has more recently been chemically synthesized. An entirely new method of biochemical synthesis of the substance, using microorganisms, has been developed in Kyowa Hakko Kogyo Ltd, under the direction of Dr Shukuo Kinoshita, and this work has opened up a new approach to the biosynthesis of various kinds of amino-acids, which in turn has made a remarkable contribution to fundamental research in the biochemistry of microorganisms (see page 211).

Academic standards in microbiology, both within and outside the university, are high, and this kind of development is nothing but the outcome of close cooperation between the university and research institutions in industry with highly academic backgrounds, together with strong support from the academic societies as well.

Another example is the pioneer work by Professor Shigeru Sakakibara in Tokyo Women's Medical College in the field of cardiac surgery (see page 212).

The Problem of Science Policy

Research and development are taking an increasingly important role in Japanese industry, and the idea that fundamental research is worth paying for is becoming popular, although not to the extent that most scientists would like.

There are two possible approaches to the problem of forging a policy for fundamental research^{2,3,5}. One is the encouragement of the general appreciation of research, and the other is the reorganization of the internal structure of the

scientific community. One should be warned, however, that although there has been extensive discussion and debate about university reform during the past several years, very little has been said about the role of the university in the context of fundamental science. Something needs to be done to rescue the university from ceasing to be a centre of research, both because of the outdated internal structure which is entirely unsuitable to maintaining its research activity and because of the unbelievably poor financial support which it enjoys.

The present system of funding research through the traditional *Koza* structure apparently favours the individualistic character of the research activity, but the cooperative approach, in a more integrated form should be encouraged. University scientists dislike the expression "organized research", because it sounds as if a whole project might be carried out under the dictatorship of a certain leader, with the other members of the group being the mere manpower. Cooperation and the integration of research should mean something different from organized project research in this sense. It should be based entirely on a voluntary system for the common good.

The lack of communication between scientists is probably the important inhibiting factor for the development of cooperative research, the results of research done both within and outside Japan is fairly readily available, but scientists have fewer opportunities of exchanging views and ideas through direct conversation. Meetings of the academic society no longer function in that way, for the number of people attending has become too large and the number of reports is ever increasing. A possible solution may be to encourage scientists to visit other institutions and possibly to stay for a time to discuss subjects of common interest. Alas, the money available for travel is not even sufficient to cover the cost of attending meetings of the society.

The mobility of faculty members, above all among universities but hopefully between universities and other institutions too, also needs to be made easier. The setting up of special chairs for professors on leave from universities seems to be a useful idea. These so-called "guest chairs", which were in evidence before the Second World War but are now defunct, are worth reexamining. A certain number of the institutes for joint use are actually operating such schemes.

The Science and Technology Agency is responsible for the overall policy for science and technology, but that for fundamental science in the universities is almost completely

left to the Ministry of Education. The present machinery within the ministry for funding research on an institutional basis and also through grants-in-aid for research is not necessarily well adapted to the situation, and a strong advisory board responsible for decision-making about university research is badly needed. This might be done by strengthening the function of the existing Advisory Council for Science Policies, *gakijutsu shingikai*, which is attached to the ministry.

There is no doubt that universities need more funding for research, but it is also obvious that there is a limit to the rate of growth of society as a whole, and this should certainly be reflected in the policy for scientific research; more balanced selection for funding is desirable. This selection should not, however, necessarily mean the most efficient, but the most effective use of the money allocated. This can only be done with full participation on the part of the scientists, not as pressure groups but as fair judges. University scientists must act not only as the consumers of financial resources, but also as advisers about their planned distribution.

The situation of the private university is in general even worse, and the financial difficulties are very serious. Although there has been considerable governmental support in the form of grants for scientific equipment in private universities, and although grants-in-aid for research have been made available to scientists in the private university during the past, much stronger support for private universities is necessary from the government.

As for the inflow of private resources into national universities, there has not been much systematic support for fundamental research from industry except for individual contracts for specific subjects in which industry is particularly interested. Recently a few industries have begun to establish foundations which support research and give awards, but more industrial finance would be appreciated. This, together with increasing support from the government to private universities, would contribute greatly to reducing the inordinate gap between national and private universities, and to encouraging integrated research activities in fundamental science and its application to industry.

¹ Armytage, W. H. G., *A Social History of Engineering*, 233 (London, 1961).

² Long, L. T., *Policy and Politics in Japanese Science: The Persistence of the Tradition*, *Minerva*, 7, 426 (1969).

³ Kakiuchi, Y., *Comment, Policy and Politics in Japanese Science*, *Minerva*, 7, 758 (1969).

⁴ Findeis, A. F., *Science*, 177, 583 (1972).

⁵ *Reviews of National Science Policy, Japan* (OECD, Paris, 1967).

Natural Disasters in Japan

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The characteristic features of Japan—for example its situation on a boundary between tectonic plates—explain its extreme susceptibility to natural disasters. Dr Terada is a former director of the National Research Centre for Disaster Prevention.

JAPAN is located in the western Pacific Ocean and is always under the influence of the warm Kuroshio current from the

south and by the cold Oyashio current from the north. Japan is also affected by cold and dry air masses which originate in the Siberian high pressure zone in winter. Further, Japan is very narrow and mountainous—there are few flat regions in fact—and the rivers are generally short and steeply inclined.

It follows that floods and landslides (Fig. 1) occur frequently at various places when it rains heavily; the northwestern regions also have to contend with heavy snow because of the combined effects of a warm ocean current flowing along the coast bordering the Sea of Japan and a cold monsoon wind from Siberia. We frequently experience severe depressions including typhoons, which cause very high seas around Japan and consequently many shipwrecks.

Japan is also well known for its earthquakes and volcanoes,

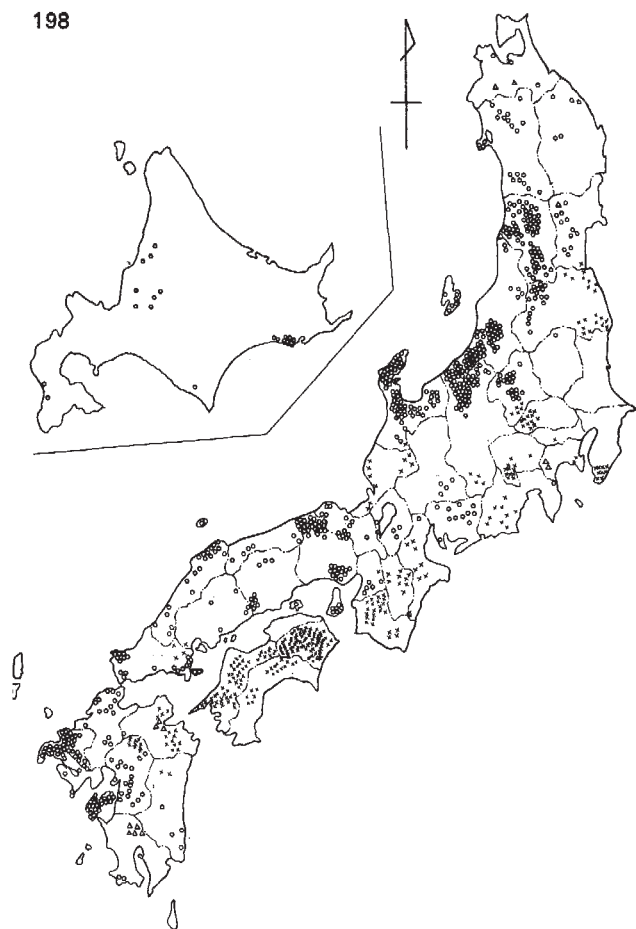


Fig. 1 Distribution of landslide zones in Japan. ○, Landslides in Tertiary layers; ×, landslides in fractured zones; △, landslides in volcanically altered areas.

and has frequently suffered particularly strong earthquakes and tsunamis. And Japan is highly populated, with most of the people living in the flat regions, so the population density is exceedingly high. When natural disasters occur, therefore, they have profound effects on the social and economic life of the country. The average damage due to natural phenomena amounts to about 200,000 million yen a year (308 yen = 1 US dollar).

Japan has always suffered from disasters like drought, famine after a cool summer, heavy wind and torrential rain, strong earthquakes, tsunamis and volcanic eruptions, but the old records of these disasters are generally unreliable.

Severe earthquakes and tsunamis that killed more than about 5,000 people occurred in 1498, 1605, 1611, 1703, 1707, 1771, 1792 (eruption of Mt Unzen), 1847, 1855, 1891, 1896 and 1923. Eruptions of Mt Fuji occurred in 864 and 1707, and in 867 Mt Aso and in 1640 Mt Komagatake erupted. In 1783 Mt Asama erupted very violently and about 20,000 died.

According to the old flood records severe disasters occurred in 1475, 1557 (storm surge in Osaka bay), 1650, 1653, 1742, 1786 (more than 30,000 persons were killed), 1846, 1896, 1903, 1907, 1910 (perhaps the severest), 1947 and 1948.

Serious damage was caused by heavy wind and torrential rain in 1281 (about 100,000 soldiers of the Korean army were drowned), 1612, 1680, 1728, 1791 (a large storm surge occurred in Tokyo bay), 1828 (the strongest typhoon ever, of estimated minimum pressure 900 mbar killed more than 10,000 people), 1856, 1884, 1911, 1912, 1917, 1934, 1936 (heavy snow), 1938 (frontal rain), 1942, 1943, 1945 (two severe typhoons), 1950, 1951, 1953 (frontal rain), 1954, 1957 (torrential rain), 1958 (frost and typhoon), 1959 (severest for 100 years), 1961 (heavy snow, frontal rain and strong typhoon), 1963 (heavy snow), 1964 and 1965.

In the old days severe famines were frequently experienced,

chiefly as a result of cold weather in summer and sometimes because of drought; some very severe famines lasted for several years. The chief ones occurred in 1640–42, 1675, 1681, 1695–96 (more than 240,000 people starved to death), 1732 (deaths from starvation amounted to 960,000), 1755 (more than 50,000 persons died), 1770–1771 (drought), 1783–87 (known as the Tenmei famine; Mt Asama erupted and a flood occurred during the period and several hundred thousand were killed, principally by starvation), 1833–39 (the Tempō famine), and 1869. Since the dawn of the Meiji era in 1868, Japan has experienced four catastrophically bad crops—1902, 1905, 1913 and 1934 (drought of western Japan, cold climate of north-eastern Japan)—but no one starved.

Severe Disasters in the Past Century

In the year 1868 Japan presented a new face to the world, bidding farewell to feudal days. Since then, the country has gradually developed and at the same time its power has increased. Various political and economic changes have also occurred and one of the results was that records of disasters became much more reliable.

In the past century, Japan has experienced about fifteen very severe natural disasters with death tolls of more than 2,000. Natural disasters causing more than 500 deaths number about forty-five in the same period (see Fig. 2). I shall consider some typical examples from among these disasters.

The most serious earthquake occurred in 1923 and had a magnitude of 7.9. The epicentre was south of the Kwanto district and Tokyo and Yokohama were entirely destroyed. About 130,000 houses were completely destroyed, the same number were damaged and about 450,000 houses were burned down. The death toll (including those missing) amounted to more than 140,000 and 100,000 were wounded.

In 1891 an earthquake of magnitude 8.4 occurred in central Japan, and long and conspicuous dislocations were found near Gifu Prefecture. Aftershocks continued for more than 10 years at Gifu. In this case more than 80,000 houses were completely destroyed and the death toll amounted to about 7,300.

In 1896 and 1933 very severe earthquakes occurred offshore, just to the east of the Tohoku district—the magnitudes were 7.6 and 8.5 respectively. In both cases, the eastern coasts of the Tohoku district were assaulted by high tides caused by exceptional tsunamis. The height of these tsunamis was 25 m at Yoshihama (1896) and 24 m at Ryori Bay (1933). In the former case more than 10,000 houses were completely destroyed or washed away and more than 27,000 people died; in the latter case more than 4,000 houses were lost and the death toll amounted to about 2,000.

Table 1 Three Serious Typhoons

Typhoon	Muroto September 21, 1934	Makurazaki September 19, 1945	Ise Bay (Vera) September 26, 1959
Lowest pressure observed (mbar)	911.9 (Murotomisaki)	916.6 (Makurazaki)	929.5 (Shionomisaki)
Radius of typhoon just before impact (km)	1,100	800	900
Meteorological tide* (m)	3.10 Osaka Bay	2.5 Kagoshima Bay	3.45 Ise Bay
Death toll (including those missing)	3,036	4,229	5,101
Houses completely destroyed	38,771	55,934	36,138
Houses washed away	4,277	2,394	4,703
Houses partly destroyed	49,295	51,385	113,052

* Height above normal.

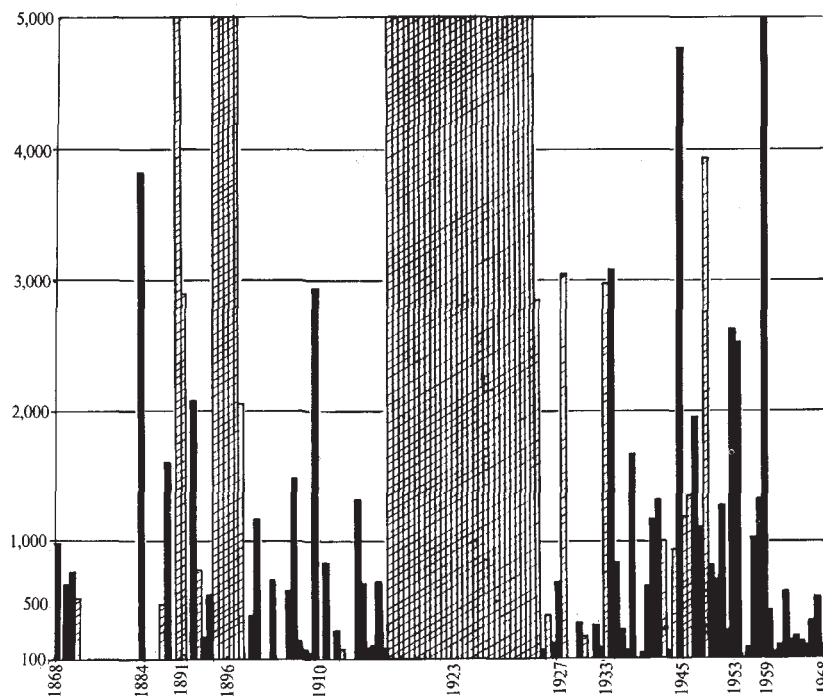


Fig. 2 Annual death toll between 1868 and 1968. —, Meteorological origin; ---, earthquakes or tsunamis.

Meteorological Disasters

In 1934 Murotomisaki weather station observed a world record low pressure 911.9 mbar when a severe typhoon passed by. The Muroto typhoon hit Osaka and severe damage was caused by the ensuing storm surge.

In 1945 the southern part of Kyusyu was severely damaged by the Makurazaki typhoon and in 1959 a severe typhoon, Vera, caused catastrophic damage in Nagoya city, especially by storm surge. The reclaimed land there was under water for 2 or 3 months until the whole dike system could be reconstructed. The damage amounted to 600,000 million yen (360 yen to \$1 at that time).

Almost every year since 1868 Japan has experienced typhoons, frontal rain and depressions, but it seems that the

damage was concentrated in the period of about 10 years after the Second World War because of the frequent typhoons shown in Fig. 2, namely in 1947 (drought and tremendous flood at Kwanto district), 1948 (Tohoku district was severely damaged by a typhoon), 1949 (three typhoons), 1950 (two typhoons), 1951 (drought and two typhoons), 1952 (typhoon), 1953 (heavy frontal rain occurred in June and July and the annual damage amounted to 700,000 million yen), 1954 (Toyamaru sank in Hakodate Bay as a consequence of a typhoon and 1,139 persons were killed in September and many fishing boats sank off Hokkaido during a severe depression in May), 1956 (two typhoons), 1957 (heavy rain at Isahaya—more than 1,000 mm fell in one day), 1958 (flood of urban area by typhoon), 1959 (Ise Bay typhoon), 1963 (heavy snowfall and landcreep), 1965 (208 fishermen were killed by typhoon), 1968 and 69 (landslide), 1970 (sinking of tankers in a very strong wind), 1971 (shipwreck of tanker).

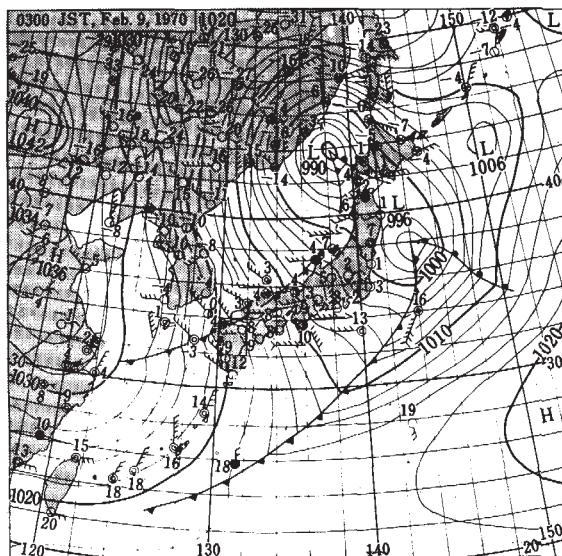


Fig. 3 Weather map for February 9, 1970.

Recent Natural Disasters

In August 1965, swarms of earthquakes occurred at Matsushiro in the central mountainous region of Japan proper, and ever since then we have detected more than 600,000 unfelt and 60,000 felt earthquakes in a period of eighteen months.

Volcanic ash mixed with pumice covers 49 per cent of the whole area of Kagoshima Prefecture to a depth of 150 m. This region is liable to damage by landslides, for heavy rain sometimes reduces the adhesion of this layer. In June and July 1969, severe frontal rain occurred causing severe damage there.

In 1969 and 1970, four large ships were sunk, namely the Boliver Maru (January 5, 1969), the Sofia-P (January 6, 1970), the Antonios-Demades (February 7, 1970) and the California Maru (February 10, 1970) (see Fig. 2). Features common to all these tragedies are the fact that the accidents occurred in very stormy weather when the ships were passing through a front extending from the centre of a depression, and that the current of the Kuroshio in the sea area near 143° E is so unstable that the current is liable to be influenced by external forces. A large tanker, the Juliana, was broken in two near Niigata on November 30, 1971, and a large quantity of oil was spilled.

The National Research Centre for Disaster Prevention

MASAMI SUGAWARA

National Research Centre for Disaster Prevention

The director of the centre explains how Japan has adopted a unified approach to research on disaster prevention.

THE National Research Centre for Disaster Prevention (NRCDP) was founded about ten years ago for four chief purposes—first, to aid in promoting and coordinating research related to disaster prevention in which several government agencies are involved; second, to establish and run a large-scale instrument for research relating to the prevention of disasters; third, to carry out basic, universal studies on disaster prevention; and fourth, to collect and collate information relating to disaster prevention.

In pursuing the first of these objectives, the NRCDP promotes and coordinates research on several subjects each year. As for the second, the NRCDP has established experimental stations to look into the damage caused by heavy snows at Nagaoka and Shinjō in the region of Japan where snow falls particularly heavily, and has set up a wave observatory on the Hiratsuka coast—about sixty kilometres south-west of Tokyo. It is also responsible for the world's largest shaking table for research into the effects of earthquakes in the region of Tsukuba New City, which is now being built sixty kilometres north-east of Tokyo. The NRCDP is also boring a hole 3,500 metres deep to measure minute earthquakes at Iwatsuki, 25 km to the north of Tokyo, as a step towards a monitoring system to give Tokyo warning of large earthquakes. And a large rainfall research installation is being built at Tsukuba New City.

Among the research projects that come under the heading of the third objective is one involving river flow analysis by means of mathematical models. Computer simulation is being used to forecast floods and droughts. Again, by combining computers with meteorological radar, a preliminary experiment to predict floods and warn of heavy rains has been carried out. Weather control experiments have also been done.

As for the fourth objective, the NRCDP collects records of strong earthquakes and publishes them. All the information about the Matsushiro earthquake has been collected, and work is at present being done on ways of investigating it with a computer.

The character of the NRCDP arises from the fact that there are several departments concerned with disasters, such as the Ministry of Construction, the Ministry of Agriculture, and the Meteorological Office. One of the reasons why the NRCDP was set up, in spite of the expertise of these departments, which covered all types of disaster, was that Japan is a country particularly susceptible of disasters and a unified effort is therefore essential.

Japan is on the Pacific Earthquake Crescent (Belt), and is frequently struck by large earthquakes. It is also on the eastern-most tip of the monsoon region, and thus susceptible to typhoons. During June and July there are often very heavy rains, and in the winter the side of the country facing the Japan Sea experiences some of the heaviest snowfalls in the world. Finally, because Japan is to the east of a continent, differences between winter and summer temperature are very marked.

But these calamitous natural phenomena are not the principal reasons why Japan is a country of disasters. If Japan had not

been favoured by nature it would not have developed in its present way. A century ago, when Japan was still a closed island, a very advanced agricultural society had already developed. Earthquakes and floods have made flat and fertile plains; heavy rainfall means a plentiful water supply, and the violent movements of the Earth's crust have created a long and scenic coastline with fine harbours. The hot and humid summer, together with an abundance of water, have made it possible to achieve high yields of paddy rice; and the cold winters have made it impossible for people to lead lazy lives.

At the time of the "opening up" of Japan a hundred years ago the population was a third of its present size, but as a sixth of the land area is flat, it is likely that, even then, Japan had the highest actual population density in the world. The pressures for the opening up of Japan came from outside, but within Japan itself the maximum possible that could be expected of a closed agricultural state had already been achieved. The concentration of population made commercial and industrial development necessary, and at the same time the advantages of having a concentration of population accelerated the pace of development.

In the past ten years the Japanese population has become increasingly urban as the economy has grown, and both urbanization and economic growth have taken place explosively. At the same time, it must be remembered, the risk of disasters has increased at an ever-growing rate. Half of the Japanese population and the greater part of industry are on the deltas and other low lands formed around indented bays by rivers. Not only is the soil vulnerable to earthquakes, but part of it has been subsiding and is now below sea level. So most of the population lives and engages in industrial activities on land liable to be damaged by earthquake, floods or tides. Although there are advantages in living and working in such close confinement on this strip of land, there are at the same time great dangers. The natural conditions of Japan are at once assets and liabilities.

The problems emanate from the natural conditions and the mode of life of those who live in them. If there is disharmony, there will be disaster. Research into the prevention of disasters has therefore to be comprehensive and integrated, and this is why the NRCDP is an integrated research organization, separate from the various different disciplines.

One particular difficulty of this kind of research is that disasters occur at times and places that cannot be predicted, and they take place for reasons and in ways that cannot always be foreseen—foreseeable phenomena would not, after all, be disasters. History witnesses that, however well thought out systems and organizations are, blind spots and oversights cannot be avoided. When one calculates the number of combinations in which potentially disastrous events can occur, it is clear that not every circumstance can be provided for. From this point of view, too, it is wisest to establish a generalized research centre for disaster prevention, without regard to academic disciplines.

Earthquake Experiments

The large experimental earthquake simulator mentioned previously is 15 metres by 15 metres, and can exert a maximum load of 500 tons horizontally. Tremors can be induced in any one direction, vertical or horizontal. Its chief characteristics are indicated in Table 1.

Table 1 Characteristics of the Earthquake Simulator

Size of vibration board	15 m × 15 m
Weight	160 tons
Vibration motor output	90 tons (× 4)
Horizontal acceleration	0.55 g
Vertical acceleration (500 ton load)	1.0 g
Maximum displacement (200 ton load)	± 3 cm
Oil pressure pumps	150 kW × 17

The vibrations are transmitted by oil pressure, and vibrations of any type of waveform can be induced by servo-valves with displacement feedback. As records of strong earthquakes are usually described in terms of acceleration, they must be transformed into displacement by digital integration with a computer, using a suitable numerical filter to exclude drift. With this "board" output is only up to about 20 Hz, but when actual seismic waves are reproduced the poor high frequency response is scarcely apparent. The seismic waves of the famous El Centro earthquake, for example, can be very satisfactorily reproduced.

Some of the earthquakes that have struck Tokyo—the 1855 one (magnitude 6.9) for example—were not of very great size but took place immediately beneath the city and thus caused extensive damage. In order to detect the phenomena that are the precursors of earthquakes, it is necessary to measure the minute tremors that take place near Tokyo. Tokyo is in a region in which the soft subsoil is very thick, so it is impossible to measure very small tremors at the surface. The plan is to bore a hole reaching to pre-Tertiary rock and to put in it very sensitive seismic measuring equipment. By the spring of 1973 the hole, 3,500 metres deep, should have been bored at Iwatsuki, twenty-five kilometres north of Tokyo. Such a hole will be full of water, with the pressure at the bottom about 350 atmos and the temperature about 90° C, depending on the soil temperature. The development of measuring instruments capable of long service in these adverse conditions, and of handling equipment and cables capable of keeping instruments in fixed positions 3,500 metres underground is very difficult. This project is notable for its very advanced instrumentation and material handling technology.

River Flow and Rainfall

The analysis of river flow by models has been carried out with the model represented diagrammatically in Fig. 1. Rain is run into the uppermost container. Some of the water in each container runs out through the side holes, and some runs through the hole in the bottom to the container beneath. The sum of the flows through the side holes corresponds to the discharge of the river; the flow through the bottom hole corresponds to infiltration. This is a simple model but it represents the extent and nature of rainfall loss, the fact that the river has various discharge components, the time lag of the discharge and so on. Moreover, if the detailed composition of the model is suitably fixed, the calculated water flow agrees very well with actual measurements. Not only is this model appropriate for flood analysis, but, if elaborations are made to it to represent melting snow and irrigation systems, the model is also applicable to drought analysis. The disadvantage of the model is that it is non-linear, so it cannot be placed in a mathematical framework, and it is impossible to determine its structure objectively and mathematically. It is only possible to search for suitable parameters by trial and error with the help of a computer. The computer results have then to be assessed by the researcher and the next set of calculations made. The loop thus formed includes human judgment, of course.

It would be difficult to distribute rain gauges over every

**Fig. 1** The model of river flow.

part of Japan and cover the whole surface of the country with a telemetric system, so the only way rainfall can be comprehensively mapped is by using meteorological radar. (The intense cloudbursts that frequently cause great damage in Japan are extremely localized, so even with a dense distribution of rain gauges it would be impossible to obtain meaningful measurements.)

The most difficult feature of rainfall measurements by radar is that there is a considerable variation with circumstances in the relation between the intensity of the radar echo and the volume of rain falling. A good way of overcoming this difficulty is to compare actual rainfall measurements with the radar echo, and to carry out simultaneous calibrations. This can be done by linking the radar and rainfall telemeters to a computer, and having the computer do the collation.

Because the radar available was in a remote place, we recorded the radar signals on a video tape recorder (VTR) in our first experiment. (Because radar signals have a short wavelength we substituted a VTR for a data recorder. The regenerated record was then changed to a digital one and fed to a computer.) The radar signals were plotted on polar coordinates.

Following the success of this preliminary experiment, the radar signals for each small segment were separated out and integrated by an analogue method. A means was devised of feeding the signal values integrated from each segment on the mesh. By slowing down the speed of rotation of the radar antenna, the integrated radar signals from the segments of the polar coordinate mesh were turned into data that could be transmitted on telephone circuits.

The computer can compensate for ground echo and other factors. The amount of rainfall can be estimated at a given moment and at a given place on the polar coordinate mesh. It has also proved possible to integrate these data in space and time—in other words, the rainfall over any region during any period of time can be calculated. The experimental analogue-integrator we built has performed well, and has shown that much can be hoped for from this method.

Problems of Predicting Earthquakes

T. RIKITAKE

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Techniques for predicting earthquakes are improving, but the work is being hampered by unrest at the Earthquake Research Institute.

MORE than 100,000 lives were lost and about 700,000 houses were destroyed, mostly by fire, during and after the great Kanto earthquake that hit the Tokyo-Yokohama area on September 1, 1923 (Kanto is the name of the area surrounding Tokyo). This was surely the worst ever in Japan, which has long suffered from disastrous events of this kind.

Why does Japan suffer from earthquakes? How can the earthquake hazard be prevented? What causes an earthquake? Is it at all possible to forecast them? In spite of widespread interest, nobody could answer these questions properly, and Japanese politicians and government officials thus became aware of the importance of understanding basic earthquake phenomena.

This was the motivation for founding the Earthquake Research Institute (ERI), attached to the Tokyo Imperial University (now the University of Tokyo), in 1925. A number of outstanding physicists, engineers, geographers and geologists of the time were appointed to chairs at the institute, but they were almost all part-time. Gradually, however, fresh graduates in physics, seismology and geology joined them in the years that followed, thus forming a research team whose energetic work heralded a new phase in earthquake research in Japan. The first director of the institute was Y. Suyehiro, originally a professor of shipbuilding engineering.

The institute, a tiny two-storied building made of reinforced concrete, was located immediately behind the university clock tower, which became world famous in 1969 because of the fight between rioting students (*Zengakuren*) and the police. As no one then knew how to construct a building that was reasonably resistive to the most serious earthquake anticipated, the building was constructed as rigidly as possible. Two seismographs with identical characteristics were placed in the basement and on the roof, and, in fact, produced exactly the same seismograms.

Only 30 to 40 people, including technicians, porters and clerks in the administrative section, worked in the institute before the Second World War. There was no sectionalism in those good old days; one could go into any laboratory and use any instrument freely, provided it was not in use. But things have changed recently because a new building about ten times as large as the original one has been built in the northernmost corner of the university campus and some 200 people are now working there. The family atmosphere has inevitably vanished from such a large community where people do not know each other very well.

Starting from Scratch

There was much to learn about earthquake phenomena in the early days of the ERI. Seismology in Japan was started off by professors who had been invited there from western countries in the years that followed 1868. After the violent Nobi earthquake of 1891, the Imperial Earthquake Investigation Committee was set up; it conducted several field studies over seismic and volcanic areas and published many useful reports.

The knowledge thus accumulated was, however, descriptive rather than scientific. Accordingly, the founders of the ERI had to start by doing very elementary experiments, like measuring ground motions as well as vibrations of a building during an earthquake and examining seismic wave propagation, in the hope of achieving a comprehensive understanding of earthquake phenomena on a scientific level.

M. Ishimoto, who was the second director of the ERI for ten years, designed and constructed a then revolutionary accelerometer by means of which the acceleration of earthquake motion was first measured. He also invented a silica horizontal-pendulum tiltmeter for measuring an extremely small tilt in the Earth's surface. K. Sezawa, an eminent mathematician, set out a general solution of elastic waves in spherical polar coordinates, and his theory subsequently had many applications to problems concerned with the propagation of body and surface waves. It was fortunate for ERI, although not for the local people, that a number of large scale earthquakes took place in Japan immediately after its establishment. The staff, who promptly made observations over the earthquake area, learned much about earthquake phenomena in this way. It is of particular importance that marked land deformations were shown up by analysing levelling and triangulation surveys carried out before and after an earthquake.

The ERI's impact during its first ten years was so remarkable that many new facts about earthquake phenomena were discovered. Probably the most flourishing period in the history of ERI was, however, the following five years in which intensive seismometric studies, electric and magnetic experiments and field studies and observations on volcanoes were undertaken respectively by T. Hagiwara, T. Nagata and T. Minakami, who were later to become leading Japanese geophysicists. Regrettably the work of the ERI had to be curtailed during the Second World War.

The ERI had a tough time after the war, although some activity continued in spite of shortages of food, experimental material and so on. Nonetheless several key papers, especially on theoretical aspects of surface wave propagation, electrical conductivity distribution within the Earth and the like, were somehow published. Since the early 1950s, it has been possible to send younger members of the research staff to foreign countries. This has resulted in the internationally minded work of later years.

As Japan's economic situation improved, so the ERI came to life once again in a more modernized form. The institute now consists of the following eighteen sections, each being headed by a professor or an associate professor—theoretical seismology, earthquake mechanism, seismicity, seismometry, explosion seismology, sea-bottom seismology, crustal deformation, geomagnetism, gravity, geothermy, geodesy, tsunamis, physical volcanology, chemical volcanology, structural geology, petrology, earthquake engineering, and soil dynamics. The ERI also runs eighteen observatories, scattered all over Japan, for seismic, crustal deformation, geomagnetic and tsunami observations. Fig. 1 shows what a crustal deformation observatory looks like. In recent years, two centres—the Strong Motion Seismograph Centre and the Earthquake Prediction Observation Centre—have been attached to the institute. There are now twenty-five professors and associate professors, forty-nine research associates, eighty-eight technicians working in laboratories and workshops, and thirty-eight supporting members in the administrative sections. Of these, thirty-nine work

at provincial observatories.

One of the features of the ERI is that it has on its staff people from all disciplines, namely, mathematicians, physicists, seismologists, geodetists, volcanologists, geomagneticists, geologists, chemists, architects, civil engineers and so on, all of whom are interested in earthquake phenomena. One can always find the right person to handle a particular problem properly. Interdisciplinary work is, for obvious reasons, specially encouraged.

Predicting Earthquakes

At this point, mention should be made of the earthquake prediction programme¹, a nation-wide project started in 1965, in which the ERI has been deeply involved. To predict the occurrence of large earthquakes has been one of the goals for Japanese seismologists over the years, although nothing systematic had ever been undertaken until a group of seismologists proposed a plan for earthquake prediction research in 1962.

From their experience of earthquake observations over a long period of time, Japanese seismologists got to know, albeit vaguely, what kind of work they had to undertake in order to be able to predict earthquakes. The result of group discussions was published in 1962 as the now famous report *Prediction of Earthquakes—Progress to Date and Plans for Further Development*², which was called the blueprint for research into the prediction of earthquakes and later came to be seen as a milestone in the research.

A long-term programme for research into the prediction of earthquakes, which followed the line of the blueprint, was actually launched in 1965 after much debate in the Science Council of Japan and the Geodetic Council, which is responsible for the coordination of geophysical observations in Japan. The Niigata earthquake in 1964 certainly seems to have accelerated the launching of the programme. In 1968, the northern part of Japan was badly shaken by the Tokachi-Oki earthquake which caused considerable damage. The importance of earthquake prediction was then argued at cabinet level, so the programme was forced to aim at actual predictions,

wherever possible, rather than at the acquisition of the data necessary for earthquake prediction.

The earthquake prediction programme embraces various disciplines. First, much stress is laid on the detection of anomalous land deformation by repeating levelling and triangulation surveys. It is believed that the magnitude and time of occurrence of earthquakes can be foretold to some extent from the size of the area covered by the anomalous crustal movement—the wider the area, the larger the magnitude. The use of geodimeters employing a laser source for electro-optical measurements of long distances has recently become fashionable. Continuous observation of crustal deformation is also included in the programme; tiltmeters and strainmeters installed in a deep vault are generally used for that purpose (Fig. 1). A prototype of a standard vault for the observation of crustal deformation has been put forward as a direct result of test observations made by the ERI over a long period.

The observation of seismicity, certainly one of the most important items of the earthquake prediction programme, has also been stressed. Although relatively large earthquakes with a magnitude greater than 4 or so on the Gutenberg-Richter scale are to be monitored by a network organized by the Japan Meteorological Agency (JMA), microearthquake observations have been conducted mostly by university workers. The ERI has played an important part in designing the equipment for such observations.

The earthquake prediction programme also finances studies of changes in seismic wave velocities, observations of changes in the geomagnetic field, examination of active faults and foldings, rock breaking tests in laboratories and so on.

Some 4,000 million yen (or \$13 million) was allocated to the programme for the period from 1965 to 1972. Salaries, costs of constructing observatory buildings, vaults and the like are met from other sources, so that this sum of money has been earmarked solely for promoting the programme. Although the budget is much smaller than that for the Japanese space project, it is certainly a lot of money for Earth science in Japan. It should also be mentioned that about eighty staff posts were specially provided by the government for the purposes of the programme.

Leading members of the ERI have participated in the programme since its planning stage, so the institute has had a lot to do with the progress of the programme. The Earthquake Prediction Observation Centre (EPOC) was thus set up in the ERI for the purpose of processing data measured by university workers. EPOC is equipped with a high speed computer and is supposed to process data relevant to earthquake prediction, which are sent there from universities, into a form suitable for the Coordinating Committee for Earthquake Prediction (CCEP). The CCEP was set up in the Geographical Survey Institute, Ministry of Construction, in 1969 and consists of about thirty specialists from universities and government institutions; it actually functions as the headquarters for earthquake prediction. Whenever CCEP foresees the possibility of a destructive earthquake in a certain area, that area is earmarked as an area of intensified observations of a certain rank depending on the assessment of the danger. It has not as yet been possible, however, to issue a warning specifying the date and magnitude of an impending earthquake.

It was timely that the proposed earthquake prediction programme was actually tested during the 1965–67 Matsushiro earthquake swarms. Matsushiro, a small town in central Japan, experienced an incredibly large number of shocks at that time. At the most violent stage 600 shocks a day were felt, including moderately large shocks from time to time which gave rise to slight damage. The ERI carried out all sorts of observations over the Matsushiro area, and, interestingly, mobile seismic observation parties often found places where many ultra-microearthquakes were occurring. Almost without exception a fairly large shock took place in such an area after a few months. The JMA summarized the results observed by the

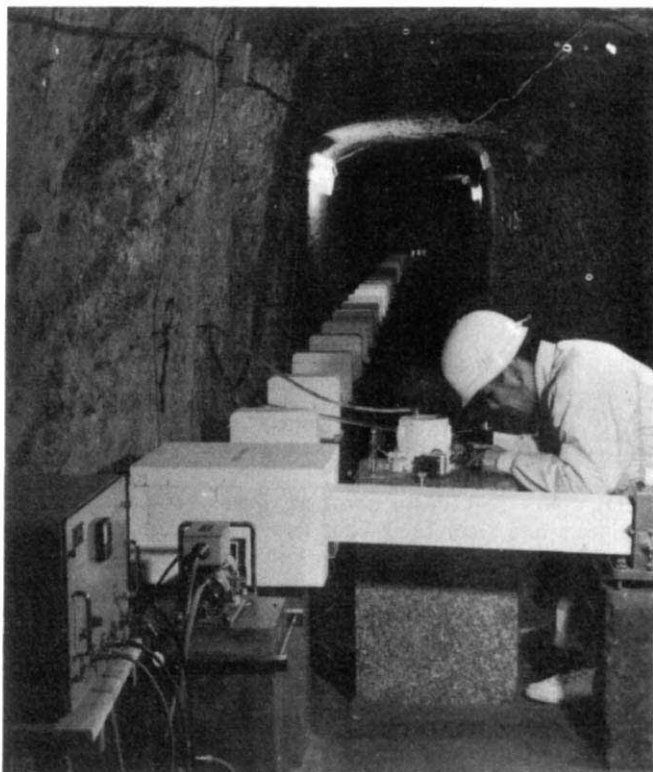


Fig. 1 Interior of the Nokogiriyama Observatory for crustal deformation, about 60 km south of Tokyo. An observer is measuring the height of water surface of a 25 m water tube tiltmeter. A 25 m silica tube extensometer with recording systems can also be seen.

ERI and other agencies and officially issued warnings of coming earthquakes to local inhabitants for the first time ever. Only a long-term forecast, covering a few months, and a very rough estimate of earthquake magnitude were released. The experience of Matsushiro indicates that the proposed programme for earthquake prediction is going in the right direction, although there are some defects that need to be improved at once.

Unrest in the Institute

To process the large amount of data observed over the Matsushiro area, the ERI hired many temporary staff, chiefly to analyse seismograms. About sixty non-regular members were working in the ERI at the peak of the Matsushiro activity. As it is a government agency it was not possible for the ERI to increase the number of its regular employees even in such an emergency. Many of the temporary employees did not want to leave the ERI even though work on the Matsushiro event had come to an end, and about twenty of them are still working in the ERI at the moment; every effort to appoint them as regular members has been made.

The non-regular members are less well paid than regular members, and also have no paid holidays or proper pensions and the like because they are paid on a daily basis. As there are also many non-regular members in other institutes and departments of the University of Tokyo, an organized movement requesting an improvement in labour conditions emerged. This movement was quite legitimate until a group of so-called neo-leftists intervened.

There was an unfortunate occurrence in the ERI in the summer of 1970 when a professor quarrelled with one of his non-regular members who had said in no uncertain terms that he wanted to become a regular member, no matter how much difficulty such an arrangement presented. Although I do not know exactly what happened, it seems that the non-regular employee got slightly injured for his pains. After that, the institute was attacked by activists who not only demonstrated but also forcibly locked up many professors. One of their slogans called for the expulsion from the university of the professor concerned in the business I have described. Such a crazy state of affairs was at one time stopped by police intervention, but the president of the university does not like to ask the police to stay there for long. As soon as the police departed, some parts of the institute were again occupied by rioters who now stay there day and night. It has been difficult for most professors in the ERI to work in their offices since then. A neighbouring institute, the Microbiology Research Institute, has recently come in for similar treatment.

It is really ridiculous that such a strike should have lasted more than two years. Research associates, technicians and the like can work in the ERI quite safely, foreign visitors and professors from other universities can enter there quite freely, and all the provincial observatories of the ERI are running absolutely normally. Most ERI members, it should be emphasized, have nothing to do with the riots. The most difficult thing for people from abroad to understand is that everybody in the ERI has been fully paid in spite of the fact that some of the members declared that they would not work in an institute controlled by "shameful professors".

It is difficult to say at the moment when the trouble will end. Whether the ERI will recover to its normal state one day is an imponderable question. One of the root causes of the trouble is that there are practically no regulations to control working conditions within the university. It was assumed in the old days that university people were all *bona fide*. I must confess, however, that the mode of administration appropriate then cannot be applied to a modern institute with 200 or more members. The professors of the ERI, many of whom are internationally known for their scientific contributions, could well be accused of paying too little attention to administrative matters.

The promotion of earthquake research, particularly in the field of prediction, is urgent in Japan. Ever since the finding of anomalous land upheaval in an area south of Tokyo in 1969, it has been feared that Tokyo, the largest city in the world, might again be hit by a large earthquake in the near future. Intensive work over the anomalous area indicates that a considerable amount of strain energy has accumulated there since the time of the Kanto earthquake. The ERI would have played a most important part in conducting various observations there if it had been functioning normally. Although the ERI is doing some work in the area, taxpayers may well say that the ERI is not working properly.

An intensification of earthquake prediction programmes is now under consideration in Japan. In view of the data already gathered, it is being strongly recommended that a dense network of electro-optical distance survey devices, a real time observation network by seafloor seismographs, monitoring systems for microearthquakes by telemetering and so on should be established. It is also important to reconsider the role of various organizations. If a large, modern institute were to be founded as a result of the debate about reorganization, the present ERI would lose its *raison d'être*.

¹ Rikitake, T., *Geophys. Surv.*, 1 (in the press, 1972).

² Tsuboi, C., Wadati, K., and Hagiwara, T., *Report of the Earthquake Prediction Research Group in Japan* (Earthquake Research Institute, University of Tokyo, Tokyo, 1962).

Japan's Electrotechnical Laboratory

F. MORI

Electrotechnical Laboratory, Tokyo

Dr Mori, director of the Electrotechnical Laboratory, describes how the laboratory has developed over the years and how it is now contributing to the national research effort.

THE Electrotechnical Laboratory (ETL) is the largest of sixteen national laboratories run by the Agency of Industrial Science and Technology, which in turn is under the aegis of the Ministry of International Trade and Industry. The number of staff at the laboratory, which has scarcely changed since 1965, is just over 800, of whom 590 are researchers, ninety of them

PhDs. No clear distinctions are made between scientists, engineers and technicians—but that is not a state of affairs peculiar to the ETL.

There are, generally speaking, four research areas involved: computers and information processing; the physics of electronics; electrical energy and its utilization; and the establishment of national standards for electrical and allied units. Much the same number of researchers are engaged on each of these types of activity.

When various projects, including those concerned with the development of the oceans or of space, are entered into, the necessary staff members are drawn from each of the groups. Every group has three or four divisions, so that there are altogether twelve divisions. In the financial year 1972 (April 1972

to March 1973) the budget, including salaries, was 4,500 million yen (£6.5 million).

The purpose of the ETL is testing, investigation, certification and research into electronics and electrical engineering, and establishment and maintenance of national standards. But the activities of the laboratory have changed over the years as national needs have altered. It is now in the process of turning into an institution concerned chiefly with fundamental and applied research.

What I shall concentrate on particularly here is the role the ETL has been assigned to carry out on behalf of Japanese industry and the Japanese economy. I should first say, however, that it is very difficult—sometimes almost impossible—to explain the characteristics of Japanese technology and scientific research, of the “innovation process” in general, in a way that is clearly intelligible to those outside Japan. Whatever understanding proceeds from such a short article as this, or from such a brief discussion of the subject, may well be misunderstanding.

“Japaneseness”

The Japanese national character, formed over the ages by the climate and geography of Japan, is markedly different from that of most other nations; the strengths and weaknesses of the Japanese are unique. Why should this be?

First, the Japanese are a homogeneous people. They are, of course, physically of a kind, and because they have lived in close proximity and have been bound to each other by powerful internal and external forces, events have influenced the whole body of the Japanese people in the same way within short spaces of time. Second, a century of government effort since the Meiji period, which started in 1868, has developed the educational system, and levels of intelligence have become quite high. Although in many cases it has been difficult to find those very outstanding individuals who could lead such relatively able people, it is true to say that when an objective has been fixed, Japanese people will work more effectively towards this goal than the people of any other nation. Without an appreciation of this background it is very difficult to understand the Japanese scientific “technique” or other social phenomena.

ETL Over the Years

A simple account of the eighty years of the ETL's existence will be useful to an understanding of the techniques of Japanese electronics and electrical engineering. The ETL began as a small testing laboratory for communications insulators in 1876 under, it is said, the leadership of an Englishman. Shortly afterwards the then revolutionary technology of electric power generation came to the fore, and the laboratory devoted its energies to research and development associated with the new techniques and to the import of foreign technology. Naturally Japanese manufacturers imported technology from the advanced countries without recourse to the ETL, and set about making Japanese-built equipment and devising their own systems; but the ETL, which had a respectable output of scientific papers and was sending scientists abroad to familiarize themselves with new techniques, contributed by emphasizing those aspects of foreign technology that would be useful to Japanese industry.

After the Second World War, on the recommendation of the Allied General Headquarters, the ETL was divided into communications and other fields. It then developed under the auspices of the present Ministry of International Trade and Industry, and the communications side grew into the present Electrical Communications Laboratories, which has a staff of about 2,000. Both laboratories continued research in electronics independently, but the ETL turned to research involving transistors, and did less and less work on the generation of electric power.

A great many Japanese private companies bought licences for the manufacture of transistors, the technology of which

was developed in the United States, but the ETL, which knew nothing of the nature of these licences, appreciated the future importance of transistors and began concentrated applied research on the subject. The first aim of the research was to make a transistor independently, the second was to use a transistor in the construction of a computer.

Transistor Development

When the ETL began its research the transistor was still in an imperfect state (represented by the point contact type or the first alloy types) but it was clear that it would be of fundamental importance for electronics in the near future. The most important thing to be done was to master the techniques of transistor manufacture for ourselves. We started from germanium oxide (GeO_2), then extracted pure germanium, produced crystals by zone refining and the Czochralski method, sectioned, ground, and alloyed, and finally developed the process to the point of manufacturing a transistor and demonstrating its operation as an amplifier. This may seem at first sight to have been an inefficient way of working, at a time when industry was using American licences to produce transistorized products; but the point of learning the technology little by little in the national laboratories was that this was a contribution to a fundamental Japanese technology. In the course of this work the ETL researchers were not merely learning but devising new processes.

In order to fix the axis of a crystal, for example, they covered the surface of the crystal with a special etching solution and constructed an apparatus that made use of the pattern of the reflected image of a narrow beam of light. In this way new devices appropriate to each stage of transistor technology, new measuring devices, and new production methods were linked together in practice. Various things were made on an experimental basis—equipment for measuring transistor parameters and the life-time of semiconductors, for example—and these devices later became very useful to the manufacturers.

While this work was going on, intensive research was also being done on transistor physics. It was clear that the transistor was the first of a family of new solid state devices yet to be developed, so it was obviously most advantageous to undertake research on the new fundamental processes rather than simply on transistors. Exploratory research was done on semiconductor physics, on the “microplasma” created when a silicon pn junction is subjected to a reverse bias, and on the effects of dislocations on electronic phenomena. This kind of physical research did not use or contribute to commercial technology; its implicit purpose was to increase Japanese knowledge of semiconductor techniques.

As for the second aim of the research, that of applying transistors to computing, an experimental transistorized computer was built quite early on using the imperfect transistors of the time, the point contact type. This adventurous experiment, in which the transistor was employed as a new element within an entirely new system, epitomizes one of the chief features of Japanese technical “philosophy”. Even if no big discoveries are made, work towards a goal will proceed with the exercise of ingenuity. The imperfections of the point contact transistor meant that the transistors in the computer had to be changed week after week, but in their attempt to create a system, the researchers gained several types of experience. It was an implicit contribution to the training of researchers, so that Japan could make a contribution to the electronic age.

Soon the junction transistor replaced the point contact type and we began the work of making a computer with a very much larger capacity, and again new objectives were set.

Foresight

The ETL is, then, a national laboratory charged with the task of developing fundamental new research without regard

to the pursuit of profit. It should be said, however, that the blossoming of Japanese electronics is due in large part to the foresight of commercial entrepreneurs in recognizing the potential of transistors for domestic goods at a time when companies in the rest of the world—even the United States—tended to be sceptical about the part that could be played by transistors in such equipment.

In addition to its role as a developer of advanced technology, the ETL has a policy of laying the foundations of an indigenous Japanese technology. We can take as an example the problem, which has been with us in the past and will continue into the future, of translating Japanese into foreign languages. This is research which is, of course, easiest to do in Japan; moreover we have to do it.

Criticisms of Copying

I should like now to comment on a criticism often heard of Japanese technology, namely that Japan is good at copying foreign technology. It is said that Japanese researchers take new technologies developed abroad, "copy" them, explore their commercial possibilities, and invest just enough in them to gain a commercial profit from them, so that technology is effectively "stolen". I would deny this. Remarks about copied technology are not new, but "copying" in this sense is not something that can be done by every nation. As it is, it requires a base, abilities, and a certain temperament. For example, as I remarked earlier, educational standards have been raised at a steady rate during the past hundred years—something which, it must be remembered, represents an enormous investment. If any other nation whose character allowed them to learn from others in a very short time, were to try to learn in this way, and if they had to start by changing their national characteristics and educational system, it might take a very long time.

The generation of magnetohydrodynamic electricity by MHD methods can be cited as another example. Research on this has been undertaken in every country since about 1960. At the ETL, MHD generation experiments have progressed from machines of 100 μ W output to those producing 1 kW, and since 1966 1 MW has been achieved under the auspices of the Ministry of International Trade and Industry's research and development programme. The importance of these experiments lies in Japan's energy problems, for the greater part of Japanese fuel requirements have to be imported. Moreover, the country is so short of space that there is a particularly bad pollution problem by comparison with other countries. It is therefore recognized that increasing the efficiency of energy output is a fundamental problem which must be dealt with.

The possible applications of superconducting phenomena to large scale magnets, for instance, was a breakthrough which, again, was made abroad. In Japan, also, individual researchers had been doing separate and detailed pieces of research, but after the possibilities of large scale machines had been recognized, the ETL made the development of magnets for use in MHD generation a part of the national research and development programme. Together with manufacturing companies and universities it began assiduously to develop a manufacturing process. We have now made the world's largest magnet for MHD generation, and the technology developed is also applicable to the magnetic levitation of ultrahigh speed trains. The Japanese are particularly good at this kind of intense effort over a short period of time.

Contractual Concepts

I should like to add a postscript about research into the first steps of applied research. Although it is not limited to research, the idea of "contract" in Japan is very much more comprehensive than in Western Europe. The ETL's appropriation in the national budget has to be rigorously audited by the finance ministry, but the ways of thinking about rights

and duties are not as superficially clear as they are customarily in Western Europe. A group of Japanese people will understand their rights and duties very fully, but not because conditions have been clearly set out. The Japanese are a people who reach mutual agreement in a deeper and more comprehensive way. Therefore because the early stages of applied research are entered with less formality in a European sense the research will be more flexible and will adapt more quickly to changes in conditions; again, unlike contractual research abroad it will not be interrupted suddenly for one reason or another. In Japan the Western European ideas of contractual research have been introduced into large scale research and development projects, but I am not sure that I know which method is the more efficient. To do research on research, perhaps it is necessary to think both as the Japanese and as the West Europeans do.

I should like to take the Pattern Information Processing System Project as another example (see also page 212). The history of computer development at the ETL began in 1957 when Dr H. Wada built a computer using transistors, the forerunner of modern commercial types. Under the national research and development programme for ultrahigh performance electronic computer systems (1966 to 1971) Japan is developing a prototype computer of world class for the early 1970s. The ETL has been assigned research work under this development programme, and it is also acting as a technical brain and a coordinator. We decided in June 1971 to undertake the PIPS project to improve the man-machine interface—and so try to overcome the defects of modern computers—and to develop pattern recognition in the context of artificial intelligence. The project is expected to extend over eight years and to cost 35,000 million yen (£50 million). As I have said, research on Japanese and Japanese script should be undertaken in Japan. There is a possibility that indigenous Japanese technology will be improved, and the recognition that we are linking Japanese to other languages is an important element of that improvement.

Future of Japanese Technology

At present the improvement of the environment, beginning with the elimination of pollution, and the creation of social welfare systems as good or better than those in other advanced countries is seen, both politically and administratively, as the general wish. And perhaps the domains of life science and social science will become a part of each other in basic scientific research. Again, there will be a tendency for industrial societies to change from a kind in which energy and raw materials are consumed to one dependent on knowledge. Then Japan has a duty to undertake international cooperation to the same extent as other advanced nations.

Under these conditions, the future of the ETL and of Japanese electronics can only be predicted in outline, but it seems that it will be necessary increasingly to seek the assistance of systems analysis and a deeper knowledge of fundamental science, and to take account of the real changes in values that have taken place in recent years. It will become more and more difficult to establish specific targets, for example; I suppose similar national institutions in other advanced countries, the National Bureau of Standards in the United States and the National Physical Laboratory in Britain face the same ideological problem.

Looking Outwards

As I said before, then, the ETL is a creation of the particular state of Japan and of its own characteristic populace. Even if we wished to change the national character, we could not do so within 10 to 20 years, so Japan will continue to do the research and development, and to create special technology, most suitable to itself. It is important that we should bear in mind that the results of the research and development can be a contribution to the world as a whole.

Oceanography in Japan

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Professor Hidaka traces the development of oceanography in Japan from its inception a century ago.

OCEANOGRAPHIC work in Japan goes back only to the later part of the nineteenth century, by which time European and American efforts had been going on for 150 years. This was probably due to the isolationist policy of the Shogunate government of the Tokugawa regime, which lasted about two and a half centuries until the restoration of the Emperor Meiji (1868).

Before this time, T. Ino had made extensive surveys along the coastal areas of the Japanese Islands; the oldest charts of the seas adjacent to Japan were, however, prepared by P. Schrenck in 1650 and were based on the surveys by M. G. Vries. Hydrographic surveys in Japan started in 1871, and the following year the first tidal observations were carried out in Tokyo Harbour.

In 1875, HMS Challenger entered Yokohama during her epic world cruise of 1872 to 1876. This event seems to have greatly stimulated the enthusiasm of Japanese scientists engaged in hydrographic work. In 1879 the Japanese government began to finance work on the biological aspects of oceanography, and the Fisheries College (forerunner of the present Tokyo University of Fisheries) was established in 1888.

The Hydrographic Department of the Imperial Japanese Navy was established in 1886, with Rear Admiral N. Yanagi as director, and soundings, bottom sampling, meteorological observations, and observations of waves, tides, currents, sea ice, and so on were soon under way.

Development in the Early 1900s

Dr Y. Wada, a meteorologist by training, was the first Japanese scientist to measure surface ocean currents around the Japanese islands. Between 1893 and 1895, he set several thousands of "drift bottles" adrift in the seas near Japan. He later resumed these operations in 1913 and, by 1917, 13,357 drift bottles had been released in the Japan Sea, the south-western Pacific Ocean and so on, of which 2,990 were collected. These operations enabled Wada to assess the general trend of the surface ocean currents around Japan and in the western part of the Pacific. The results were published in 1922.

From 1918 onwards the Hydrographic Department quite frequently carried out observations in the open sea; sonic sounding began in 1925. The data of the survey vessel HMS Mansyū are well known among scientists throughout the world, and several other survey vessels—HMS Yamato, Komahashi, Matue, Kosyū, Musashi and Yoda—made big contributions to oceanographic research by obtaining a great deal of data from the seas adjacent to Japan and in the western Pacific. Captains R. Shigematsu and S. Kishindō (afterwards a Rear Admiral) were instrumental in the operation of these ships, and Dr S. Ogura is another man who has made a significant contribution to research on the tides and tidal currents near Japan.

In 1897, oceanography became an important feature of Japanese fisheries research, with T. Kitahara, Dr K. Kishinouye (ichthyology), K. Okamura (algae) and T. Nishikawa (pearl) as the chief authorities. In 1909, hydrographic observations started officially in the seas around Japan under the name of the "fundamental investigations on fisheries". Projects were

led by people like Okamura, T. Kitahara, T. Okada, T. Terada, and so on.

In those days several young oceanographers were sent to Europe to study under B. Helland-Hansen and A. Merz in Germany. An Ekman current meter was first used in 1918 by T. Kumata in the southern waters of central Japan, and equipment like Richter-Wiese reversing thermometers, Nansen total immersion hydrometers, Knudsen pipettes and burettes were first imported and used in Japan at about this time. The research vessels then available were RV Ten'ō Maru (1,633 ton), Sōyō Maru (203 ton) and Ten'yō Maru (230 ton). Similar research was carried out by K. Nishida in Korea, which was a part of Japan at that time.

Observations and explanations of seiches in lakes and bays (often called "secondary undulations of oceanic tides") were actively made and propounded by S. Nakamura, K. Honda, T. Terada and others, and were published in about 1908.

Stimulated by the Antarctic expeditions led by people like Shackleton, Amundsen and Robert Scott, Lieutenant C. Shirase sailed deep into the Ross Sea on board the Kainan Maru in 1910–11. He eventually reached a spot 80° 05' S on the Antarctic Continent and named several places, such as Yamato Setsugen (Yamato Snowfield) and Okuma Bay.

In 1920, T. Okada, a meteorologist and director of the Central Meteorological Observatory, Tokyo, established the Imperial Marine Observatory in Kobe in the hope of establishing a Japanese capability for manufacturing chronometers and navigational and oceanographic instruments, which were not available in those days and before that could only be imported. Later, however, this observatory became well known as a pioneer in the study of physical, chemical, geological and biological oceanography. Dr K. Suda joined the observatory in 1922, and visited Europe in 1926 to study physical oceanography under H. Jeffreys, B. Helland-Hansen, H. U. Sverdrup and G. I. Taylor. His aim was eventually to develop physical oceanography in its widest sense in Japan, where, as in most other countries, the emphasis had been chiefly on the biological side. In 1927, I joined the group in this observatory; at the same time a small surveying vessel MS Syunpu Maru (125 ton) was built. Two years later Y. Matsudaira, whose interest was plankton, also became a member of the group.

Suda returned from Europe in 1928; more observations were carried out in the Japan Sea between 1928 and 1932, and in the South-western Islands (the waters surrounding Kyusyu and Okinawa) in the summers of 1933 to 1935.

During the Pacific War three more marine observatories were established in Hakodate, Maizuru and Nagasaki, together with the section on oceanography at the Central Meteorological Observatory in Tokyo.

In 1917, the Hydrographic Department completed its depth charts of the seas around Japan. It had also released 10,000 drift bottles from 1894 onwards, of which 500 to 700 were recovered.

Captain S. Kishindo of the Hydrographic Department had long been concerned that the exact determination of the positions of a warship in the Kuroshio area during naval operations was difficult because of the rapidly varying currents there. For this reason he set out to calculate these short period current variations by applying Bjerknes's dynamic calculations to the Kuroshio area at frequent intervals.

During the Pacific War, it was planned to build eighteen research vessels (between 200 and 800 ton) to provide the raw data for these dynamic calculations. Actually, however, this

plan was not completed and only six vessels (200 ton each) could be built before the end of the war.

HMS Mansyū, under the command of Captain R. Shigematsu, was more active in hydrographic survey work than any other vessel of a similar type. Between 1925 and 1930, Shigematsu did a great deal of hydrographic research in the north-western part of the Pacific Ocean, down to depths of 5,000 m or more. S. Kishindō remodelled and re-equipped HMS Komahashi so that it became the best available in the world at that time, as regards both the accuracy of its observations and the reliability of the data obtained.

During the ten years before 1942, more than thirty thousand observations were made, covering the area from the equatorial to the northern part of the western Pacific Ocean and from the surface of the sea down to its floor, 5,000 m or more below. These data were not even available to scientists, so nobody could utilize them before the end of the hostilities. M. Tsuchiya afterwards used them to ascertain the existence of the equatorial undercurrent in the western Pacific, while M. Uda and K. Hasunuma inferred the existence of the subtropic countercurrent in the Pacific.

The Fisheries Experimental Station of the Department of Agriculture and Forestry was established in 1929. This institute holds a conference each year for the benefit of the heads of the fisheries organizations of all the prefectures in Japan, and after each meeting oceanographers from the navy and the universities take part in a discussion about what mutual cooperation is possible in oceanographic research.

Pre-war Oceanography

M. Uda joined this same institute in 1932 and took command of the multiple-ship observations in the Japan Sea from then until 1941, and in the Pacific Ocean off the eastern and southern coasts of Japan from 1933 to 1943. The number of research vessels engaged in this cooperation amounted to fifty or more and observations were made in the entire Japan Sea and out to a distance of 1,000 miles from the south coast of Japan. There is no doubt that these multiple-ship surveys contributed immensely to the clarification of the hydrographic features of the western Pacific and its minor and year-to-year variations. In particular these surveys threw more light on the strange behaviour of the Kuroshio. Most of the vessels concerned were, however, called into service after 1943, so the activities of Japanese oceanographers were gradually curtailed until almost no oceanography was being done in Japan at all.

The close connexion between meteorological and oceanographic factors through the so-called air-sea interaction means that the rice crop in the north-eastern corner of Honsyū Island must be influenced by the water temperature off the coast and the air temperature above the sea surface. For this reason, the Central Meteorological Observatory built the RV Ryōhū Maru (1,200 ton) in 1937 with the idea of carrying out both meteorological and oceanographical observations. (In 1970, another boat, RV Keifū Maru (2,200 ton), was launched with the same purpose in mind.)

Early in the summer of 1929, the non-magnetic ship MS Carnegie, belonging to the Carnegie Institution of Washington, entered Yokohama. Suda and I went to Yokohama to visit Captain J. P. Ault and his staff on board. This was a vessel equipped with Nansen bottles and Richter-Wiese reversing thermometers, and its appearance acted as a stimulus to Japanese oceanographers, who were always eager to improve the methodology and accuracy of their hydrographic observations. Sadly, it was less than six months before this non-magnetic ship was blown up in the south seas and Captain Ault died.

In 1936, I was busy at the Imperial Marine Observatory, Kobe, editing *The Manual of Oceanographic Observations* with the object of establishing methods for obtaining exact and universal data from the sea. This first edition of this manual

was a cooperative effort on the part of R. Sekiguti (tides), Y. Miyake (chemistry), Y. Matsudaira (biology) and myself (general oceanography and hydrographic observations), and although it has been revised frequently, it still remains the standard manual of oceanographic surveys in Japan.

In the same year, H. Tominaga, M. Ishibashi, Y. Miyake, Y. Matsudaira, myself and others sailed southwards on RV Ryōhū Maru to collect seawater suitable for the preparation of secondary standard seawater—Knudsen's standard seawater was then becoming more and more difficult to import into Japan. This standard seawater was used in Japan during the later part of the Second World War and was later sent to the Scripps Institution of Oceanography, La Jolla, California, where, according to the report by N. W. Rakestraw, the comparison with Knudsen's standard turned out to be quite satisfactory.

A landmark in Japanese oceanography, the foundation of the Oceanographical Society of Japan, took place in Tokyo on January 28, 1941. T. Okada was the first president.

Oceanography after the War

When the Second World War ended in August 1945, almost no oceanographic research was being done in Japan, and many changes were then made by the Allies that had a direct bearing on oceanography.

The Central Meteorological Observatory and the Hydrographic Office were transferred to the Department of Transportation because there were no longer any national armaments in Japan. The Fisheries Experimental Station was reorganized into eight regional fisheries laboratories responsible for investigating the eight areas around Japan (including freshwater regions).

The Oceanographic Society of Japan, founded in 1941, gradually resumed its activities in the years that followed the end of the war. On May 25, 1948, the society met at the Fisheries Experimental Station and Okada expressed his intention of retiring from the position of the president; I was then elected as the second president and retained that post for almost nineteen years until 1967.

After the war, Japan was very often a participant in international cooperative ventures—for example, the International North Pacific Cooperative Research Project (NORPAC) (Canada, Japan, and the United States) in the summer of 1955, and the International Equatorial Cooperative Survey in 1956 (Japan, France and the United States). Then came Japan's involvement in the International Geophysical Year (IGY) of 1957–58, the International Indian Ocean Expedition (IIOE) of 1960–64 and the International Cooperative Survey of the Kuroshio, which started in 1963.

Here I must mention the establishment of the Ocean Research Institute at the University of Tokyo. A few days before the Seventh Pacific Science Congress—held in Quezon City, Philippines, in 1953—about ten oceanographers met at a UNESCO conference to decide whether UNESCO should establish an international institute of oceanography in south-east Asia. I was the oceanographer representing Japan at this conference. The proposal was, however, not carried at the conference, so Japanese oceanographers and fisheries scientists then became eager to establish an institute of oceanography in Japan by themselves. In my capacity as president of the Oceanographical Society of Japan I was asked by these Japanese scientists to make representations on their behalf to the Japanese government. The negotiations started in 1961 and after three years of heated discussions the senate of the University of Tokyo decided in June 1963 that the university would accept the plan to attach the institute to it. The Ocean Research Institute was thus born on April 1, 1964, with myself as the first director.

At present, the institute has fifteen sections covering all fields of oceanography and fisheries, ninety-eight scientific personnel, thirty-seven clerks, and seventy-six crew. It has

two research vessels, MS Hakuho Maru and MS Tansei Maru, the former being a well equipped boat of considerable size (3,226 ton) which makes an annual cruise in the Pacific Ocean for more than 100 days. The MS Tansei Maru is also well equipped, but of a size that is smaller yet appropriate for oceanographic work in the seas around Japan. The present director of the institute is M. Nishiwaki.

Universities and Oceanography

In Kyōto University, a course in physical oceanography was started in 1919 at its Geophysical Institute, whose professor, T. Nomitsu, published highly instructive papers on the theories of ocean currents and other dynamical oceanography and potamology. Nomitsu retired in 1945 and S. Hayami succeeded him in 1946. After Hayami's retirement in 1962, the chair went to H. Kunishi. At the University of Tokyo, a course

in physical oceanography was established in 1942 in the Geophysical Institute. K. Hidaka was transferred from the Imperial Marine Observatory, Kobe, and appointed professor there until his retirement in 1939, when K. Yoshida was appointed.

In the Tokyo University of Fisheries, which was established in 1949 as the successor to an institute which had undergone several changes of names, the professorial staff are M. Uda, H. Niino and T. Sasaki. In the Tokyo Kyōiku University, Tokyo, Y. Miyake has served as the professor in chemical oceanography. In 1935, the Laboratory of Physical Oceanography was established in the Institute of Physical and Chemical Research with T. Sasaki at its head. Sasaki contributed much to the development of oceanic engineering in Japan. M. Kuroda of the same institute succeeded in constructing GEK in Japan, now widely used in most of the research vessels in this country.

Marine Technology in Japan

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Japan has always made extensive use of the sea, and the Japan Marine Science and Technology Centre will help to provide the multidisciplinary skills needed to tap oil, gas and manganese nodules from the seafloor.

THE standard of living of the Japanese and the growth of Japanese industries have benefited from the sea in many ways. The Japanese now consume almost 60 per cent of their animal protein intake in the form of sea fish, processed and unprocessed. The Japanese fishery industry caught 9.3 million tons of fish in 1970, and although the number of fishermen is gradually decreasing, 570,000 people still ply the coastal waters and further afield (as of 1970). It is estimated that 11.8 million tons of living marine resources will be required in 1975 in order to meet the growing demand.

On the 10,000 kilometres or so of Japan's coasts are distributed some 1,000 ports serving domestic and international sea traffic. In 1969, 1,600 million tons of cargoes passed through these ports to supply industries with raw materials and the people with food and other goods. The total tonnage of sea cargoes is expected to reach 5,000 million tons in 1985. Those living on the coastal plain and in inland areas alike visit the seaside for recreation, of course, and, in 1970, 83 million went to seaside resorts for their holidays.

With the help of advanced technology and rationalized shipyards, the Japanese shipbuilding industry built some 10.5 million tons of shipping in 1970. Shipping exports contribute in no small way to the expansion of international trade.

To supply industry with the materials it requires and to raise the standard of living of the people, Japan has to seek more benefits from the sea through advanced exploitation of marine resources and utilization of the marine environment. In 1969 the Council for Ocean Science and Technology recommended the Prime Minister to encourage the five projects which it thought would serve as a springboard for that aim; first, comprehensive and basic surveys and studies of the continental shelf around Japan; second, investigation of and research on the marine environment and the management of oceanographic data and information; third, the study of the development of aquaculture; fourth, the development of remote controlled underwater oil drilling rigs and related facilities and technology; and fifth, the study and development

of both the pioneering and more well known techniques required for marine development.

As well as these five principal projects, the recommendations also proposed the development of the technology required for the efficient utilization of seawater, for exploitation of mineral resources on the seafloor, for intensive utilization of marine protein resources and for exploitation of unutilized or underutilized living marine resources.

An interministerial committee was duly organized by the thirteen ministries and agencies of the government that administer marine affairs. The Science and Technology Agency, the Ministry of International Trade and Industry, the Ministry of Transport, the Ministry of Construction and the Fishery Agency of the Ministry of Agriculture and Forestry are all playing important parts in implementing the national marine development projects already mentioned.

Government Effort

In 1969, 25 per cent of the domestic production of oil and 30 per cent of the coal came from the seabed around Japan, but the potential deposit of these fuel resources on the continental shelf is not yet fully delineated. The Geological Survey of the Ministry of International Trade and Industry has been engaged since 1969 on geological and geophysical surveys of the continental shelf employing seismic and airborne magnetic and gravitational sensing devices. The surveying capability of the said body will be strengthened by the building of a survey ship with a computer aboard, which will be completed by 1973. The Hydrographical Department of the Maritime Safety Agency is conducting geophysical and bathymetric surveys of the continental shelf, with the aim of preparing topographical and structural maps of the seabed; its survey capability has already been intensified by the acquisition this year of a new hydrographic survey vessel the Shoyo-Maru (1,950 tons). Sixty-two sets of maps, which cover the whole continental shelf around the country, will be prepared by 1976. And the Geographical Survey Institute of the Ministry of Construction has started detailed mapping of the coastal seabed with the objective of allowing coastal space to be more intensively utilized. Along with these surveying activities, improvements in instruments such as the bucket-type dredger, the suction-type corer, the vibrohammer and so on, and in techniques for employing these instruments, data processing and mapping, are being studied at the institutes mentioned above.

If a better understanding is to be gained of the interaction between ocean and atmosphere, and the generation of typhoons

in the north-west Pacific, and if fishery activities are to be more effective and the navigation of the merchant fleet safer and more economic, more intensive oceanographic data collection and processing are required. Accordingly, improvements to meteorological survey vessels and the deployment of networks of monitoring buoys were included among the national projects.

In 1969 the Meteorological Agency acquired a new survey ship, the *Keifu-Maru* (1,796 tons); several more survey ships of similar size are, however, considered necessary if an overall survey of the Pacific is to be made. The agency has started deploying a network of fifteen medium and large meteorological buoys at quite large distances from the Japanese archipelago, and the basic work on the development system of buoys that can be used in deep ocean areas is being conducted at the Institute of Physical and Chemical Research. As regards data transmission from buoys, a comparison of simplex-ARQ, time-diversity and other systems is being made by the Maritime Safety Agency, the Meteorological Agency, the Radio Research Laboratory and several other institutes, with the backing of the Science and Technology Agency.

The routine work of collecting, processing and disseminating information and data about marine phenomena has also been intensified—for example, the Ocean Data Centre of the Maritime Safety Agency has been equipped with a new computer and has started collecting and processing the data concerned with tidal currents and marine pollution.

In connexion with the intensive utilization of the coastal area, information about waves and swells is badly needed. Port and harbour research institutes have, together with the Bureau of Harbour Construction of the Ministry of Transport, set up fourteen stations for observing waves and swells. The data will be processed by a central system.

Aquaculture in the sea is expected to help satisfy the demands of the Japanese for particular kinds of fish. Although aquacultural techniques produced 550,000 tons of living resources in 1970, it is expected to produce 1.2 million tons in 1985. In order to achieve this goal, however, increases in the production of fry and spawn, and the location of breeding grounds by means of "fishery engineering", are needed. Production of hundreds of millions of prawn spawn and fry of red seabream, flatfish and several other fish in their hundreds of thousands has already been done. The spawn of abalone and scallop are now also produced by the million. In order to enhance the productivity of Seto Inland Sea, the Fishery Agency entrusted to the Inland Sea Fish Farming Association the operation of five fish farms. In 1972 it is planned to release a total of 209 million fry and spawn of prawn, scorpion fish, red seabream, flatfish, octopus, abalone and blue crabs. The agency also aims to open similar farming stations in other seas around the country.

To improve economics of aquaculture, of course, more of the fry and spawn released need to be recaptured eventually. This can be achieved by providing a better environment through physical, chemical and biological control of the breeding areas. Efforts are being made to collect the basic data relevant to this aspect.

A recent intensification of international regulations on tuna, herring, salmon and king crab stocks has spurred on research on the culturing of these species to a commercial size under closed and controlled conditions. Experiments on the raising of salmon fry in submerged cages are under way at Tohoku Regional Fishery Research Laboratory, and king crab larvae have been successfully reared to the glaucothoë stage in their thousands.

The ocean-going Fishery Agency research vessel *Kaiyo-Maru* has been on several long cruises—to the south Pacific, the south Atlantic and the Antarctic, for example—in a search for unexploited fishery resources. The agency is considering building another vessel for experimental fishing at depths of 2,000 to 3,000 metres.

Among many basic and pioneering research and development topics, the problems of staying underwater, at greater

depths and for longer times than are at present possible, is being tackled actively. Conventional aqualung diving is very common among the Japanese, both as a profession and as a sport; some 23,000 are licensed as divers by the Ministry of Labour and some 4,000 are employed as divers in industries concerned with coastal construction, salvaging and fisheries. (Those women, locally called *Ama*, who dive for shellfish and seaweed are not included in these figures.)

The increasing scale of coastal construction—exemplified by the building of a long suspension bridge linking Honshu and Shikoku, which has a maximum span of 1,500 metres and a depth of 50 metres—and the developments in offshore drilling for oil and gas, both in Japan and abroad, require men to work underwater at greater depth and for longer times than is possible using conventional diving techniques. In 1965 the Science and Technology Agency accordingly launched a project—later nicknamed *Seatopia*—with the ultimate target of enabling men to live for a month at a depth of 100 metres. The building of an underwater habitat to accommodate four divers, together with the supporting tender equipped with a deck decompression chamber and a personal transfer capsule, was completed in 1971. In the summer of this year, the Japan Marine Science and Technology Centre was entrusted by the Science and Technology Agency with a preliminary habitation experiment at a depth of 30 metres. The stay at this depth was for just two days and the experiment was a success; a mixture of nitrogen, oxygen and helium was used as the ambient gas. The next step is to live at a depth of 60 metres and the appropriate trials will be undertaken next summer.

Along with the continuation of the project *Seatopia*, the Science and Technology Agency entrusted the centre with the installation of a high pressure simulation chamber system at the centre. This system consists of a central wet chamber, two dry chambers with subchambers connected to the central wet chamber, an automatic environmental control system and facility for recovering helium gas. The central wet chamber and two dry chambers can accommodate four divers and can simulate conditions at a depth of 500 metres. Installation of the system will be complete early in 1973.

The development of diving technology has also stimulated efforts on the part of a research group of the Radio Research Laboratory of the Ministry of Posts and Telecommunications to improve the intelligibility of the human voice in helium. The train of speech waves is divided into segments with equal duration, a portion of each segment deleted, and the remainder expanded to the full duration of the original segment. The click produced at the boundaries between segments is removed by means of a smoothing function. Vocal sounds generated in this way are found to be much more intelligible.

The Council for Ocean Development, a revamped Council for Ocean Science and Technology with a brief to investigate a wider spectrum of marine affairs, has now started to review and revise national projects in marine science and technology. More emphasis will probably be laid by the government on the conservation of the marine environment and the abatement of pollution by means of developments in marine science and technology.

Industrial Participation

Faced with the initiation of national marine developmental projects in 1968, *Keidanren* (the Federation of Economic Organizations of Japan) set up a committee to investigate the role of industrial concerns in marine development. The committee recognized the need to establish a research and training institute for marine science and technology so that the cooperative research and development activities of both governmental and industrial establishments should be fostered. Centre was thus actively canvassed by members of this committee. The proposal for the Japan Marine Science and Technology

mittee and eminent people in marine science and technology. The centre was authorized by the Minister for Science and Technology as the exclusive institute defined in the Marine Science and Technology Centre Act. The centre is accordingly to be financed both by industry and by the government.

The Japan Marine Science and Technology Centre (JAM-STECC) will primarily be concerned with the development of the advanced technology that will be required jointly in various aspects of marine development, the installation of large-scale research facilities for common use by the government, industry and the universities, and the education and training of scientists and technologists in advanced marine science and technology. The centre will be well equipped and will have a staff of more than 200 by 1975.

Those Japanese industries with a marine bias take a keen interest in offshore oil and gas exploitation, civil engineering in coastal areas and, in the not too distant future, the exploitation of manganese nodules on the deep ocean floor.

Japanese shipyards are well equipped to build offshore drilling rigs of any size and for any purpose and shape. A semi-submersible rig called Hakuryu 2 was built last year; it can work at a depth of 200 metres and is capable of drilling down to 9,000 metres below the seafloor. Development work on a remotely controlled drilling rig capable of working on the seafloor at a depth of 250 to 300 metres and of drilling through 9,000 metres is being jointly carried out by several industries under contract with the Ministry of International Trade and Industry.

Amino-acid Production by the Fermentation Process

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The discovery in Japan of how to manufacture *l* amino-acids with micro-organisms was a tremendous stimulus to research cooperation.

ESTABLISHING a commercially applicable method for the synthesis of sodium glutamate has long been a subject of interest to chemists. Of the various problems involved, one of the most difficult was how to separate from the synthetic product, *dl* glutamate, the one isomer, *l* glutamate, that has the effect of enhancing the flavour of foods when added in appropriate amounts. I considered the whole problem myself while I was engaged in microbiological research, and came to the conclusion that microorganisms could well be useful.

The proteins of living cells contain *l* amino-acids, which are biologically synthesized from carbohydrates and nitrogenous substances contained in the medium. But although living cells can manufacture *l* amino-acids, these are vital to the synthesis of their own cellular proteins, and so would not be expected to be available "on tap" for other purposes.

There was nothing in literature at that time to suggest how amino-acids could be extracted from cells. And, anyway, how could the synthesis of glutamate be made to dominate the synthesis of other amino-acids?

Cellular synthesis of amino-acids is normally stably balanced, otherwise the process of protein synthesis would not work properly.

Some kind of change in favour of glutamate synthesis must clearly be made to occur if economic production of glutamate is to be feasible. Bearing in mind the difficulties, I started doing screening research on microorganisms from various sources, and in 1957 I discovered a novel species, later named *Corynebacterium glutamicum*, which seemed to suit my purposes perfectly.

When the bacteria were cultivated in an agitated medium containing glucose, ammonia and minerals at pH 7, about 30 g l⁻¹ of glutamate was excreted into the medium by the cells. Other amino-acids, such as alanine, aspartate and glutamine, were often found in the mixture, but in negligible amounts. All glutamate produced by this microbiological method was definitely confirmed to be the *l* form.

These results were surprising, and the method proved to be a most important breakthrough. It was clear at that time that there is some subtle mechanism operating which causes

glutamate synthesis to become predominant in the cells and excretion to take place.

The key substance involved in the mechanism turned out to be biotin, and the amount of it present in the medium was found to be critical. Glutamate production occurs when the biotin content of the medium is 1 to 5 parts in 10⁹. At higher concentrations glutamate production is greatly reduced. These results were first reported at the International Symposium on Enzyme Chemistry in Tokyo and Kyoto (1957), and there were immediate repercussions in the form of a movement to establish a nation-wide research organization.

Microbiological research groups in universities and government research bodies were as a consequence organized in such a way that the basic and academic problems of amino-acid biosynthesis could be coherently studied. Special research funds were given to these groups by the government, and their common aim was called "basic research on amino-acid fermentation". Government support for these academic groups continued for three years, from 1957 to 1959.

As a result of this financial support, the literature on fermentative production of amino-acids promptly mushroomed. The symposium on amino-acid fermentation was a natural outcome; it was first held in April 1959 and since then has taken place every spring and autumn. A body called the Association of Amino-acid Fermentation was established at the same time, both to organize the symposium and to publish the papers every six months. Financial support for the association comes from individual membership fees and from industrial companies as supporting members.

As a direct result of these activities, subjects ranging from basic ones like cell wall permeability to more practical ones like production control and process designs are now discussed at the symposium. Much biochemical work has been done during the past ten years or so, and a completely new technological field, fermentations by metabolic control, has been firmly established. Most of the *l* amino-acids are now commercially available, and most are made by fermentation methods.

Another recent outstanding achievement has been nucleotide production by microbial means. Starting from the production of flavour-enhancing nucleotides such as inosinic acid and guanylic acid, various others like AMP, ADP, ATP, GDP, GTP, FAD and NAD can now be produced in commercial quantities.

The literature in the nucleotide field became so abundant, in fact, that the Association of Amino-acid Fermentation had to change its name to the Association of Amino-acid and Nucleic Acid Fermentation.

Development of Cardiac Surgery in Japan

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Much of the research into cardiac surgery depends on donations from industry and individuals.

WHEN cardiac surgery was first started in 1949, research was done in the most difficult of circumstances, for the Tokyo Women's Medical College was without money and resources because of the effects of the Second World War. At that time, people were homeless and short of food and money, so financial support for medical research was out of the question. It was even necessary to convert gas masks for anaesthetic purposes. Most of the research apparatus was similarly makeshift. In the midst of all this, research on cardiac surgery still went ahead. At first hypothermia was studied, then brain cooling, and later it was found that the combined use of hypothermia and our artificial heart-lung machine made for successful surgery.

In 1953 a new disk-type centrifugal artificial heart (oxygenator) was successfully devised and used clinically. This device oxygenates the venous blood to arterial blood; it was found to need less blood for priming and its disks rotate horizontally instead of perpendicularly. It needs almost an hour of preparation time, however, so we devised the disposable-type bubble oxygenator, which we are using at present. A combination of hypothermia and the use of the oxygenator led to a useful lengthening of the inflow occlusion time—to about 3 hours in most cases.

Work on artificial heart valves eventually produced the SAM valve, first clinically used in 1965. Basic studies on the prevention, mechanism and treatment of brain embolia, pulmonary

oedema, acid-base disturbance, and so on, which may appear suddenly during surgery, have also been made.

In 1965 the Heart Institute of Japan was established and specialists in cardiology, paediatric cardiology and surgery were recruited so that research in these fields could be expanded. At this time also, the first emergency ambulance, with all resuscitation facilities, and a coronary care unit were established. Doctors, nurses and assistants have been assigned to these ambulances and many acute cases of myocardial infarction have been saved. The result has been a drop in the mortality rate from arrhythmia in myocardial infarction.

These contributions to society aroused considerable public interest, and gifts of money from various industries and individuals have allowed us to set up a research fund, and thus expand our studies into cardiac diseases. For example, we are developing a scheme in which the management of post-operative patients is carried out by means of a computer. Parameters like the patient's blood pressure, pulse rate, body temperature, respiratory rate, central venous pressure, urinary volume are monitored and the computer prints out the diagnosis and treatment. The system also allows the necessary injections to be given automatically to the patient.

Another plan is to use the computer in the education of medical students—for example, the computer could display the X-ray, phonocardiogram, electrocardiogram and symptoms of a typical case of Fallot's tetralogy.

A fund has also been established from the donations made to researchers in cardiac diseases by large industries and this has been used to establish the Research Centre of the Heart Institute of Japan; it is well equipped and is open to anyone from another university who is interested in cardiac research. This kind of development helps medical progress considerably.

Pattern Information Processing System Project

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Dr Devey describes how government, industry and the universities are co-operating in a large computing project.

THE long tradition of a strong and friendly cooperative interaction between government and industry in Japan is well illustrated by the largest prescriptive research and development project, the Pattern Information Processing System (PIPS) project, being conducted under the National Research and Development Programme (NRDP) of the Ministry of International Trade and Industry (MITI). The aim of the NRDP is to develop the large scale technologies which are urgently needed for the development of Japan's economy. Such projects are under the leadership and full sponsorship of the Japanese government, with the close cooperation of industry and the universities.

The NRDP was established by the Japanese government in 1966, and one of the first projects to be launched was the Super-high Performance Electronic Computer System project, which ended on March 31, 1971. The budget was \$27.78

million. The new PIPS project is in part an extension of this project, but there is a significant difference between the two.

Scientists at the Electrotechnical Laboratory (ETL), part of MITI, concluded that much more knowledge is needed about pattern recognition and artificial intelligence, and a plan for a research and development programme in these areas was submitted for approval. The Japanese electronics industry knew of the plan and countered with one of their own; namely, that the basic studies to be conducted by the ETL should become a part of a large scale research and development project oriented towards specific needs and objectives. Industrial influence is strong in Japan, so its view prevailed and the PIPS project began in July 1971. It is scheduled to end on March 31, 1978, and is being coordinated by the ETL.

The investment to be made by the Japanese government during the eight year period is 35,000 million yen, or \$100 million at the exchange rate of 1971. The ETL seems to control \$20 million while Japanese industry, through the Agency of Industrial Science and Technology (a part of MITI), will support contract research to the approximate tune of \$80 million. Additionally, industry is required to contribute \$80 million to the project. Thus the project represents a total

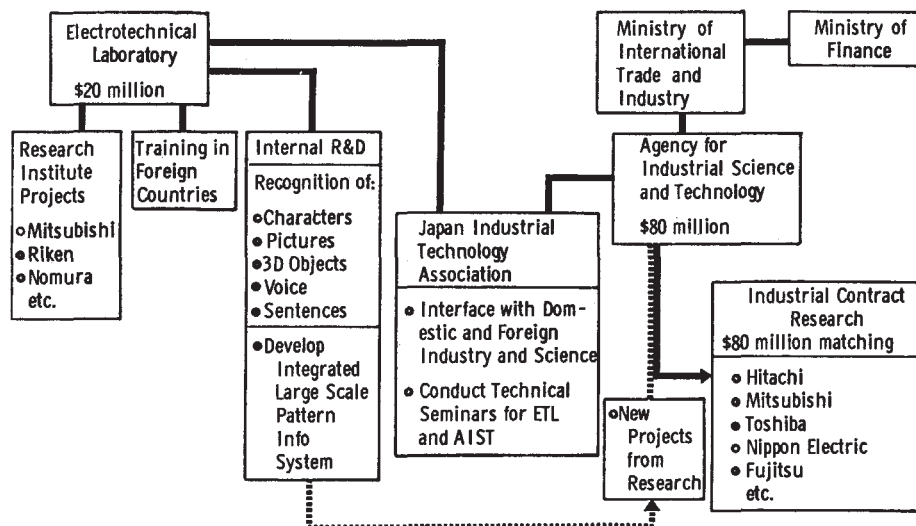


Fig. 1 Organization of the PIPS project (incomplete).

commitment of \$180 million. (The 8 : 1 ratio of funds budgeted for basic research as compared to applied research again forcefully illustrates the high cost of support for work done by industry.) Participation by university researchers seems to be tertiary in nature and is discussed later in this article. The basic government investment of \$100 million is four times larger than for any of the other eight national projects, suggesting the importance attached to PIPS.

I regard PIPS as an inanimate system capable of sensing a pattern (characters, pictures or three-dimensional objects, for example), identifying the nature of that pattern, relating that information to a data base of information (scene analysis) and then deciding on and taking a course of action for the control and manipulation of an output device which performs a useful function. All this is to be done without human intervention. The full attainment of the objectives of the PIPS project would result in the ultimate contribution to productivity in technological processes (both manufacturing and service) as they are now understood. Advanced capabilities of this kind would introduce new dimensions into product design and increase flexibility in the production process. Machines would increasingly perform routine tasks, thus releasing humans from the need to perform dull and repetitive operations for which they are ill-suited.

Japanese industry expects PIPS to provide independence from IBM, and, later, to generate a huge world market for Japanese electronic computers. This was forthrightly stated by representatives of the Japanese computer industry and the Electrotechnical Laboratory. The objective of ETL is, however, subtly different from that of Japanese industry, for it believes that it is not enough only to offer good computers to the world; others have tried that approach and failed. The ETL concept is that pattern recognition/artificial intelligence combined with good computers is what is needed to "beat IBM" in the world marketplace which, to the Japanese, also includes the USA.

The objectives of Japanese industry and of ETL are therefore compatible, even though differences continue to exist in operational matters concerned with PIPS. Further, the PIPS project is ideally suited to the objectives of current Japanese science policy, which stresses the need to develop more capability for the shift to an information-oriented society and to expand further Japan's "internationalized" economy. It is intended that science and technology be used as a weapon as international competition becomes more and more intense.

Fig. 1 is an organization chart of the PIPS project, prepared from information gleaned during long discussions with a number of Japanese who are knowledgeable about the project and who were involved in its planning.

Dr Hiroshi Nishino is the director of the PIPS project. Once the annual budget is approved by the Ministry of Finance, however, Nishino is unable to make even minor changes in

the planned programme without first receiving approval from AIST. One gets the impression that the present mechanism is more cumbersome than would exist in the United States.

The actual mechanism for awarding contracts to industry is not clear, but it seems that this is accomplished by the AIST acting on advice from the ETL.

The close and cooperative interaction between the Japanese government and industry is the consequence of a tradition established well before the Second World War. Thus several giants of Japanese industry (Mitsubishi, Toshiba, Matsushita, Nippon Electric Company and Hitachi) were influential in establishing the PIPS project; they all have annual sales of several thousand million dollars. A previous director of the PIPS project, Dr K. Sakurai, told me that PIPS was established "not so much on scientific principles as on the basis of needs of industry".

Current science policy in Japan calls for government investment in research to increase and for the promotion of research activities in private industry. Government investment is to be concentrated on those research activities that private industry cannot undertake on its own, such as PIPS. The Japanese look to the United States for models of how to develop their programmes in this area. And in 1970, MITI decided that "think tanks" should be fostered and developed as a matter of urgency.

The Mitsubishi Research Institute, as one example, operates in the "think tank" mode and is involved in PIPS. It was founded about three years ago, and now has some 300 employees, many of whom perform on an *ad hoc* basis, going to the institute on loan from one of the Mitsubishi subsidiaries. There seem to be thirty-five or so subsidiaries, and another 100 associated companies to call on for talent. *Ad hoc* task groups are assembled to work on special problems, and Dr T. Ito, chief robotics investigator at Mitsubishi in Osaka (trained at Stanford under Professor J. McCarthy), at present has three men on assignment with the institute.

Most universities in Japan are under the aegis of the Ministry of Education, but MITI has made informal arrangements for university researchers to be involved in the PIPS project, and it is quite possible for a university researcher to work at the ETL, for example, and to be reimbursed for expenses incurred in the process (travel and living costs away from home). The ETL can also pay certain allowances for research and development conducted in university laboratories. Researchers in the university are civil servants and their salaries cannot be supplemented by another government agency, so it seems that the ETL can reimburse the university for costs other than salaries, wages, fringe benefits and indirect costs. It is also true that the interests of the Ministry of Education come first, and the adoption of an important new programme in that ministry could result in termination of the arrangements.

Japanese Railways on New Lines

HIDEO SHIMA

National Space Development Agency of Japan, 3-5 Shida-Lamamatsu-cho, Minato-ku, Tokyo

Rail travel in Japan has been revolutionized in the past ten years by the advent of the "bullet train".

THE New Tokaido Line (NTL), that section of the *Shin Kansen* system between Tokyo and Osaka, was opened to the public on October 1, 1964. By September 23, 1972 it had carried its 500 millionth passenger and could boast a complete lack of casualties in its eight years of operation (Fig. 1).

Following the satisfactory performance of the NTL the *Shin Kansen* is now being extended in three directions. A part of the New San-yo Line was put into operation in March this year (Fig. 2).

How they Run

More than a hundred trains now run each way every day on the NTL at intervals of as little as five minutes during rush hours. The fastest travel at an average speed of 175 km h^{-1} .

The earliest trains leave Tokyo and Osaka at 0600 and the latest trains arrive at these stations a little before midnight, thus leaving 6 hours or so free for inspection and maintenance of the track and the electric feeding system. Japanese National Railways is paying the utmost attention to the inspection and maintenance of both rolling stock and fixed installations with the object of keeping a high standard of safety and comfort at high speeds.

The NTL was built to supplement the traffic capacity of the Old Tokaido Line, which was being fully utilized in the early 1960s and would not have been able to meet the increasing demands of the rapidly growing national economy. One very important decision was to build the new line only for express passenger trains—local passenger trains and freight trains are

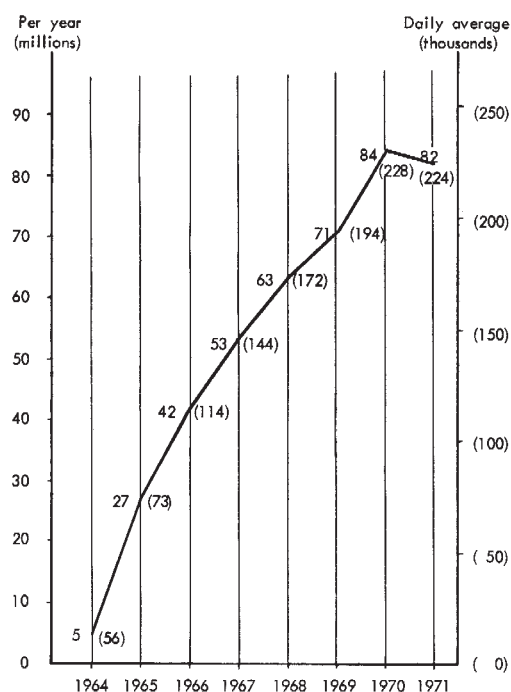


Fig. 1 Passengers on the New Tokaido Line. Number carried each year and the daily averages.



Fig. 2 High speed railway lines. —, New Tokaido Line (in operation); ---, New Sanyo Line (under construction); ···, three high speed lines to be constructed; —, three high speed lines proposed.

confined to the old line. Adding a line of the same kind to the old mixed line that carried both slow and express trains would only have raised the total capacity by a factor of two, but segregation of fast and slow traffic, as on the roads, allows the total traffic capacity to be increased threefold with ease. Local stations on the old line will only be served by stopping trains, so local trains are no longer obliged to stand still at local stations to let the expresses pass them by. Thus on the old line the local trains are speeded up, and the local stations better and more frequently served as a consequence. The NTL has only thirteen stations, including Tokyo and Osaka, while the Old Tokaido Line has more than a hundred.

The new line does not always follow the old route, and much of it is therefore constructed quite separately from the old line; this makes for greater safety.

It was quite natural for us to decide to run electric multiple unit (EMU) express trains on the new line, for we had already



Fig. 3 A bridge on the New Tokaido Line. Note the slenderness of the structure.

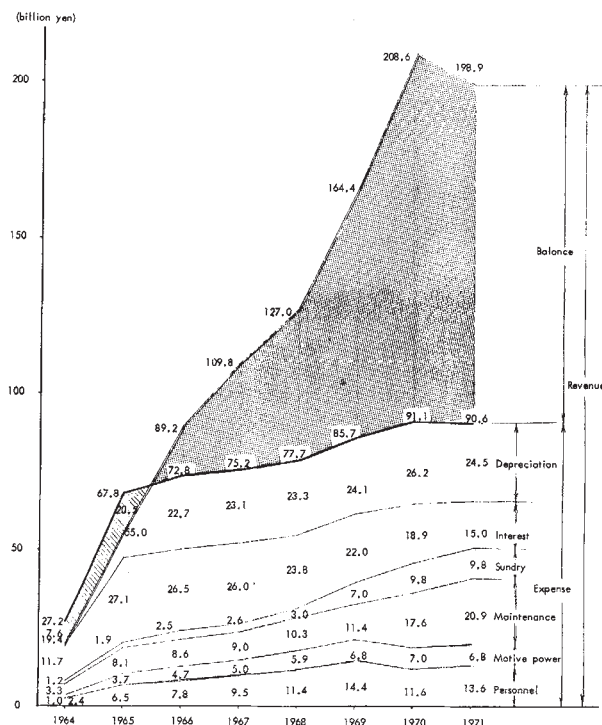


Fig. 4 Financial aspects of the New Tokaido Line.

had many years of satisfactory experience of both electric and diesel trains. Japanese National Railways had confidence in the performance of EMU trains in every respect; safety,

comfort, reliability and economy. And long experience of air spring bogies assures a very comfortable and steady ride at high speeds, even with power bogies. Moreover, with EMUs that have all axles powered, the whole weight of the train is "adhesion weight", and there is no fear of slipping or skidding under conditions of high accelerations or heavy electric braking.

The new line was built to accommodate EMU trains only, so the standard loading for track and bridges was very small compared with that for heavy locomotives (Fig. 3).

The last and most important decision, as far as the NTL is concerned, was the adoption of the standard gauge rather than the narrow gauge (3.5 foot) which used to be the general standard of Japanese National Railways.

As the new line was to carry express passenger traffic rather than freight it was considered that it was not so vital to be able to move into or out of the existing old system. The benefits to be gained by the application of modern advanced railway techniques—such as more efficient electrification, more advanced signalling, electronic operation, which are inapplicable to an older line with a century long tradition—together with the benefit attained by the adoption of standard gauge in speed, safety, comfort and so on, were traded off against the inconvenience of not being able to transfer from old to new and *vice versa*. After heated discussions, it was at last decided to build the new line in standard gauge.

We believe, however, that the knowledge and experience we gathered during the year's study we had to make on the narrow gauge railway—how to get the most out of the narrow gauge system—has contributed significantly to the success of the New Tokaido Line (Fig. 4).

Japan in Space

HIDEO SHIMA

National Space Development Agency of Japan, 3-5 Shiba-Lamamatsu-cho, Minato-ku, Tokyo

Dr Shima, president of the National Space Development Agency, sets out Japan's future plans for space research.

THE study of modern rocketry started in 1955 when Professor H. Itokawa made a test-firing of his tiny "pencil rocket" at his laboratory on the campus of the Tokyo University. This was a thin metal tube, not much larger than a pencil, fitted with a pointed nose and tail fins and packed with a propellant akin to gunpowder. Since then people at Tokyo University have continued their basic studies and development work in rocket engineering and have gradually increased the size and performance of their rockets (Table 1).

In 1958 they succeeded in launching their first sizeable sounding rocket, K-6; it reached an altitude of 50 km and was used for the measurement of temperature, wind, cosmic ray intensity and atmospheric pressure. On February 11, 1970, the first Japanese satellite, Osumi, was put into orbit by means of their L-4S-5 rocket.

There are altogether four Tokyo University satellites now in orbit; the last one, Dempa, was launched on August 19 this year by their Mu-4S-4 rocket. They are all being used for purely scientific purposes.

The rockets developed by Tokyo University are all of the multi-stage solid propellant type, with rather simple control

systems, but their performance has so far proved to be quite satisfactory for their intended uses.

National Effort

In 1960 the National Space Activities Commission (NSAC) was established, as an advisory organ to the Prime Minister,

Table 1 Brief Record of Development, Tokyo University

Year	Satellite	Rocket	Attained altitude km	Objective
1955	—	"Pencil" 18 × 230 mm 190 g	—	Flight test
1958	—	K-6	60	Sounding
1961	—	K-9L	350	Sounding
1965	—	L-3	1,040	Sounding
1966	—	L-3H	1,800	Sounding
1970	Osumi	L-4S-5	340 × 5,140	Experimental test
1971	Tansei	Mu-4S-2	990 × 1,110	Experimental test
1971	Shinsei	Mu-4S-3	870 × 1,870	Scientific measurement (No. 1)
1972	Dempa	Mu-4S-4	250 × 6,560	Scientific measurement (No. 2)

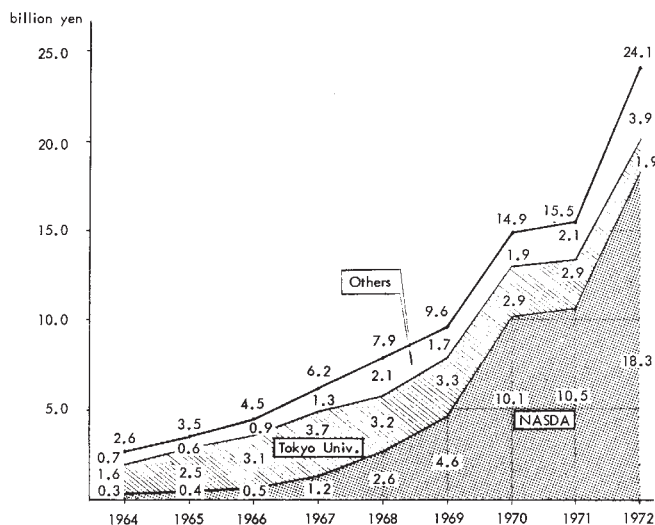


Fig. 1 Expenditure on space development.

to conduct investigations and to deliberate on important space development activities. It classified the space activities into two categories: those involving scientific studies, and the practical application of artificial satellites to such fields as communications, meteorological measurements, navigation, geodetic surveys and so on. It was decided that all the scientific studies should be carried on by Tokyo University while the practical applications would be looked after by government agencies.

Following this decision, NSAC reorganized itself in 1968 into the Space Activities Commission (SAC), and, in 1969, the National Space Development Agency (NASDA) was established in place of the former National Space Development Centre (NSDC) to consolidate the country's practical space development activities (Fig. 1).

In October 1969 the SAC adopted the new Space Development Programme (1969). This programme has been amended from time to time, in line with the rolling budget system, to keep abreast of the changing needs and nature of the nation's space problem. The greatest alteration was made in 1970, following the establishment of the general technical cooperation

Table 2 Proposed Satellite Programme

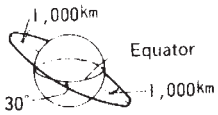
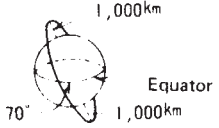
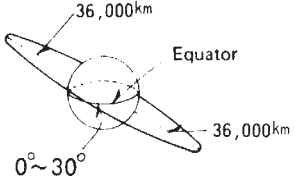
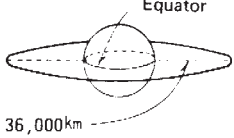
Satellite	Mission	Orbit						Launching
		Weight	Altitude	Inclination	Type	Launching	rocket	
		kg	km	angle		year		
Engineering Test Satellite-1 (ETS-I)	Rocket launching technology satellite tracking and control technology, extension of antennas	~ 85	1,000	30°	Circular	1975	N	
Ionosphere Sounding Satellite (ISS)	Observation of worldwide distribution of critical frequencies and so on	~ 125	1,000	70°	Circular	1975	N	
Engineering Test Satellite-2 (ETS-II)	Stationary satellite launching technology, attitude control of stationary satellite and other functions	~ 130	36,000	0°~30°	Synchro-nous	1976	N	
Experimental Communication Satellite (ECS)	Space communications tests, improvement of satellite function	~ 130	36,000	0	Geo-stationary	1977	N	

Table 3 Future Application Satellites

	Mission	Weight kg	Orbit	Launching year
Meteorological satellite	Continuous meteorological observation from space; collection and dissemination of meteorological data	250-300	Stationary	Projected 1976
Communications satellite	Communication with moving objects and isolated islands; emergency communication	250-300	Stationary	Requested 1976
TV relay satellite	Domestic TV relay to Asian countries including Japan	300-500	Stationary	1976
Navigation satellite	Navigational aid, navigation control, safety communication and other services for airplanes and ships	250-350	Stationary synchronous	—
Geodesic satellite	Establishment of geodesic reference points	60-80	Circular orbit of 1,000 km	—
Earth resources satellite	Technology for earth resources survey by satellites and its application	300-500	Polar orbit	—

agreement between the United States and Japan (July 31, 1969).

The agreement allows for the import into Japan of United States space techniques, up to the level of the Thor-Delta rocket, provided that they are not classified. The revised Space Development Programme (1970) envisages the development of the launching vehicle N, with fluid first and second stages, in the following way:

(1) First stage and strap-on booster: production under licence in Japan of US Thor first stage with solid strap-on boosters; (2) second stage: development and production in Japan with US technical assistance—an extension of the development plan of the former Q rocket, the third stage of which is well under way; (3) third stage: introduction of finished products from the United States for the early phases. The satellite programme is shown in Table 2.

The objective of our new programme to develop the launch vehicle N with technical aid from the United States is to proceed as fast as possible, to fill the technological gap and to

attain for ourselves sufficiently high technical standards to be able to participate in the world space effort in a true sense: that means the practical use of artificial satellite techniques for the benefit of mankind. We have kept well up to schedule with the programme, and we look forward to launching the first geostationary satellite in 1977. Because the development schedule is so well advanced, some other new projects are being considered by the various government agencies (Table 3); one of them is a meteorological satellite for the Global Atmospheric Research Programme (GARP), and a start will almost certainly be made on it next year. Decisions about the proposed communications satellite and the TV satellites, both for domestic use, are still pending.

All these three satellites are too heavy for the N vehicle to launch into geostationary orbit in 1976, so they will probably be launched by special arrangement with the United States.

We will at that time be preparing for the launch of the second generation of these satellites by means of our own N vehicles.

Calcium Ions and Muscle Contraction

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The Ca ion has many functions in living organisms. In this article, the mode of action of the Ca ion in regulating the contractile processes of muscle through the troponin-tropomyosin system is briefly described.

ONE of the characteristics of muscle research in Japan is the close personal contact and willing cooperation that exists among research workers. This pleasant atmosphere was the result of the paternal leadership of Professor H. Kumagai, who in 1955 invited young muscle scientists to join a research group in which enthusiastic and heated discussions on muscle contraction could take place. The problem implicit in the title of this article has also been grappled with under these conditions.

The mechanism of such a complex biological phenomenon as muscle contraction can be examined in two different ways. One is concerned with the underlying elementary process, and the other with the regulatory mechanism through which this process comes into operation as a biological function. The elementary process of muscle contraction involves the interaction of myosin and actin in the presence of ATP (MgATP). On the other hand, the Ca ion plays an indispensable and unparalleled role in turning the interaction of myosin and actin into a real function^{1,2} and its place in this regulatory mechanism may correspond to that of ATP in the elementary process (Fig. 1).

The first indication of the crucial role of the Ca ion in the contraction of living muscle came at almost the same time as

the establishment of the myosin-actin-ATP system by Szent-Györgyi and his school³ in 1941–42. Three years after the work of Heilbrunn⁴ in 1940, Kamada and Kinoshita⁵ injected a minute quantity of Ca ions through a micropipette of diameter 2 to 5 μm into a single muscle fibre, which responded by contracting locally in a reversible manner. Unfortunately, this elegant pioneering work was not developed in war-torn Japan; in the meantime, Heilbrunn and Wiercinski⁶ presented essentially the same result. These remarkable observations, however, were then ignored for more than ten years by most muscle scientists, probably because the elementary process of muscle contraction, namely the interaction of myosin, actin and ATP, does not require the presence of the Ca ion.

Establishment of the Ca Theory

The wide recognition of the part played by the Ca ion is chiefly based on several findings^{1,2,7} reported between 1959 and 1961. First, it turned out that the contractile processes *in vitro* are regulated by quite low concentrations of Ca ions; 10^{-7} M Ca ion keeps the contractile system in a relaxed state, and the presence of 10^{-5} M Ca ion activates it fully. Second, the sarcoplasmic reticulum, the internal membrane system, pumps up Ca ions from the surrounding medium in the presence of ATP. The capacity and affinity of the membrane system for Ca ions are sufficient to keep the contractile system in a relaxed state.

These data allow a fairly detailed picture of the sequence of events during contraction of muscle to be built up. The action potential evoked by the transmitter derived from nerve terminals finally reaches the interior of a muscle fibre through the T-system—an extension of the sarcolemma—and exerts an effect on the terminal cistern—the swollen part of the sarcoplasmic reticulum in close contact with the T-system—to

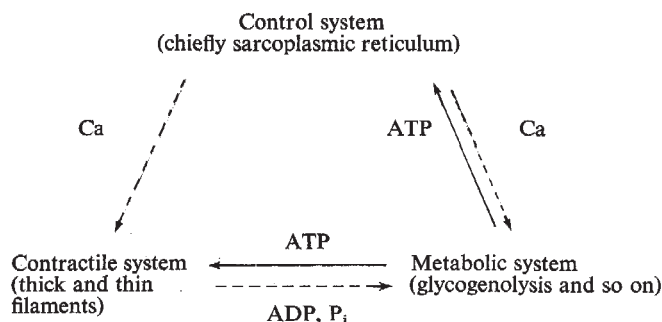


Fig. 1 Schematic representation of the functional organization of muscle.

release the Ca ions accumulated there. Ca ions then reach the contractile system by simple diffusion and induce the interaction of thin filaments, chiefly composed of actin, with thick filaments made up of myosin. When the action potential dies away, Ca ions are recaptured from the contractile elements by the whole surface of the sarcoplasmic reticulum and relaxation follows. It is of considerable significance that glycogenolysis, one of the principal energy sources for contraction, is also initiated by the same concentration of Ca ions as that which activates the contractile system⁸.

Troponin as the Receptive Protein

At first sight it seems strange that the Ca ion was ignored for so long after the injection experiments mentioned above. An explanation may, however, be found in the report published in 1963 that the regulatory function of the Ca ion requires a corresponding protein system different from myosin and actin^{1,2,9}. (It was later shown by Kendrick-Jones *et al.*¹⁰ that, in molluscan muscle, the Ca-receptive site is located in the myosin molecule; thus the regulation mechanism involves an interesting phylogenetic problem.)

This regulatory protein system, composed of tropomyosin and troponin, a new protein, is distributed along the actin filament at intervals of 38 to 39 nm (Fig. 2 and refs. 1 and 2). The function of tropomyosin, a fibrous protein about 40 nm long, was thus clarified some seventeen years after its isolation by Bailey¹² in 1946: it mediates the effect of Ca ions on troponin bound to the actin filament. (The discovery of the new protein system led to the isolation of new myofibrillar proteins like α -actinin, β -actinin and M-protein, which are involved in the structural arrangement of thin and thick filaments; these proteins, together with troponin and tropomyosin, are called "regulatory proteins"¹³ by contrast with the chief contractile proteins, namely myosin and actin.)

It must be emphasized that the Ca ion is not a simple activator of the contractile system. In the absence of Ca ions troponin, in the presence of tropomyosin, exerts an inhibitory effect on actin filaments. When Ca ions are bound to troponin, this inhibitory action does not take place and contraction follows; thus the Ca ion behaves as an inhibitor of inhibition, or a depressor^{1,2}. Substantial support for this idea has come

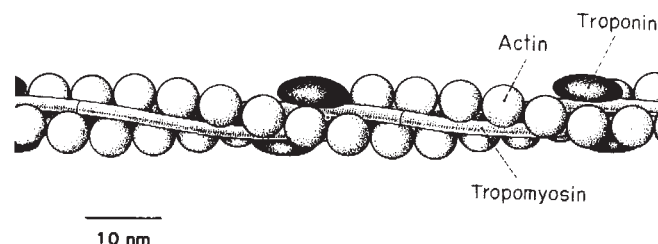


Fig. 2 A model for the fine structure of the thin filament. One tropomyosin molecule combines with one troponin molecule and seven actin molecules. The functional integrity of this morphological unit has recently been noticed and discussed¹⁴. (Fig. 5 in ref. 2 as modified by I. Ohtsuki.)

from the work of Ishiwata and Fujime¹⁴ in Oosawa's laboratory, which is based on the measurement of the flexibility of the actin-tropomyosin-troponin complex using quasielastic light scattering technique.

Troponin is not a single protein but a complex of three components^{15,16}. One component (of molecular weight 22,000 to 23,000) can act with tropomyosin to repress the interaction of actin with myosin. The light Ca-binding component (of molecular weight 17,000 to 18,000) opposes this repressing action; this effect is scarcely influenced by Ca ions. The heavy tropomyosin-binding component (of molecular weight 38,000 to 40,000) inactivates the derepressing action of the light component in the absence of Ca ions, that is in the relaxed state, through its interaction with the light component. It thus seems that the derepressing action of Ca ions is not exerted directly on the inhibitory component, but indirectly through the interaction of the other two components¹⁷.

The subtle structural change that takes place in the thin filament—the troponin-tropomyosin-actin complex—under the influence of Ca ions has become one of the vital problems in muscle science¹⁸; the answer will undoubtedly provide a crucial clue about the interaction of myosin and actin. In this way, studies on the regulatory protein systems are now closely connected with those on the elementary process.

Protein System and Living Fibres

Another remarkable contribution of Japanese scientists to the study of muscle is the so-called "skinned fibre", a muscle fibre from which the sarcolemma has been removed, which was developed by Natori¹⁹ in 1949. This is quite a suitable material for investigating the relationship between contractile processes and the concentrations of Ca ions, and also the mechanism by which Ca is released from the sarcoplasmic reticulum. The confirmation of the role of Ca ion with the help of this kind of fibre²⁰ has certainly bridged the gap between the experiments on injection of Ca ions into muscle fibres and those involving extracts of the protein system. The proposal that a "Ca-induced Ca-release mechanism" is at work in the sarcoplasmic reticulum^{2,21,22} is also based on experiments with skinned fibres.

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Activities of the National Institute of Genetics

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Active research involving many different aspects of genetics has led to exciting discoveries at the National Institute of Genetics.

THIS institute, director D. Moriwaki, was established in 1949 as the governmental institution for fundamental studies of genetics, and consists at present of ten departments.

The annual report publishes all the contributions, but here I want to summarize some of the genetic investigations carried out in the departments.

Population Genetics

The head of one of the most active groups in research, the department of population genetics, is Motoo Kimura, who has contributed to the modern development of the mathematical theory of population genetics, and the problems of molecular evolution. In 1968, his theory that a majority of nucleotide (and amino-acid) substitutions in evolution are the results of random fixation of selectively neutral or nearly neutral mutations rather than due to "positive" Darwinian selection was published in *Nature*. This theory, now known as the neutral mutation-random drift hypothesis, has caused a great deal of controversy in the field of evolutionary genetics.

His previous studies, following the work of R. A. Fisher and Sewall Wright, was on the stochastic processes in the change of gene frequencies by natural selection. He had played a major part in the development of the mathematical method, the diffusion model, which has proved to be of great value in examining the problems of gene frequency change in finite populations. Kimura's formula, for example, on the probability of gene fixation had been used by Alan Robertson to develop his theory of selection limits in animal breeding.

This line of investigation has been extended in two directions. Takeo Maruyama, working on the subdivided population structure, has extended the work of Wright, Malécot, Kimura and Weiss. This will be useful in analysing protein polymorphisms in actual populations, and is in addition an excellent contribution to mathematical genetics. On the other hand, Tomoko Ohta, working on the linked genetic systems, has succeeded in solving the difficult problems of evaluating linkage disequilibrium and the associated overdominant effect caused by random genetic drift in finite populations. In collaboration with Kimura, she has also worked on many problems of molecular evolution. Last year, Kimura and Ohta published a theory that a majority of protein polymorphisms represent transient phase of molecular evolution caused by random frequency drift of neutral or nearly neutral mutations.

In this connexion, I want to quote an old inscribed sentence, in the institute library, "The history of the Earth is recorded in the layers of its crust; the history of all organisms is inscribed in the chromosomes". These words relating to the discovery of the ancestors of common wheat by genome analysis in 1946, now appear to have a more realistic meaning.

Biochemical Genetics

The silkworm is favourite material for genetic studies at our institute. T. Tsujita, the head of this department, carried out genetic and biochemical studies of two lethal mutant strains,

lethal lemon and albino larvae. He found that the albino gene (*al*) is a simple recessive gene which localizes on the fifth chromosome. Three genes $+^{lem}$, *lem* and *lem*¹ (lethal lemon) form a multiallelic series on the third chromosome and their dominant to recessive relationship is in the order of $+^{lem} > lem > lem^1$.

Embryos homozygous for *al* or *lem*¹ develop normally into young larvae which hatch by chewing the egg chorion and grow normally during the first instar, but lethality appears immediately after the first moult. The phenotype of lethal albino larvae resembles that of lethal lemon larvae; in both mutants a small amount of melanin pigment is produced in the cuticle layer of the hypodermis. The mandibular cuticle does not develop sufficiently, however, due to defective phenylalanine metabolism, so that they cannot eat mulberry leaves, and starve to death after the first moult.

In lethal lemon larvae no sepiapterin reductase activity was detectable. Similar abnormal pterine metabolism was found in lethal albino larvae, and it is inferred that a step of sepiapterin formation is blocked in their main pteridine activities.

It was found that *al/al* or *lem*¹/*lem*¹ larval extracts have a lower activity of phenol oxidase than normal larval extracts, and it was suggested that both mutant larval extracts also have a lower activity of phenylalanine hydroxylation. It seems that in both mutant larvae abnormal pteridine metabolism has a close relation to defective phenylalanine metabolism.

Morphological Genetics

Y. Tazima (head of department) and his colleagues are continuing studies on radiation- and chemical-mutagenesis in the silkworm which is also extensively used here in mutation experiment. Extending their work on the dose-rate effect in mutation induction, they have studied the problem of "repair in mutation process". The conventional method for these studies is split-dose irradiation, and the decrease in mutation frequency is regarded as an indication of the repair of radiation-induced lesions. Such treatment of silkworm spermatogonia, however, invariably resulted in the enhanced mutation frequency. By applying split-dose irradiation to spermatids, in which DNA synthesis no longer occurred, they were able to demonstrate the "repair" as a decrease in observed mutation frequency. They then examined the effect of metabolic inhibitors on repair process by their administration during the period between the two exposures. Chloramphenicol and puromycin, both inhibitors of protein synthesis, have been found to disturb the repair, in contrast to non-inhibitory effect of hydroxyurea, an inhibitor of DNA synthesis.

In order to use sensitive mutants for this study, they carried out comparative studies on radio-sensitivity among strains. Using embryonic killing as a criterion, they extracted three sensitive, two intermediate, and two resistant strains. The most sensitive was a strain characterized by a recessive gene *rb* which blocked a biochemical step from ³⁰H-kynurenine to anthranilic acid in tryptophan metabolism. It was six to nine times as sensitive as the most resistant strain, Kansem, with regard to the induction of dominant lethals as well as recessive visible mutations in spermatogonia. Neither the lack of recombination, nor the deficiency of excision enzyme(s) seemed to be responsible for the high sensitivity. Mutation frequency is commonly measured by the specific loci method using egg colour mutants. These workers have recently developed a very sensitive test system for the detection of chemical mutagens in polluted environment.

Physiological Genetics

Drosophila is also used as an experimental animal. C. Oshima, who heads this department, has studied the correlation between productivity and viability in *Drosophila melanogaster* and also deleterious genes in natural summer and autumn populations.

Induced Mutation

The head of the department of induced mutation is T. Kada. The first experiments by Terumi Mukai to measure the spontaneous mutation rate for genes having very small effects on fitness ("viability polygenes") were carried out here. Using an ingenious method and after counting some one million flies, he obtained the startling result that mutation rate for such viability polygenes is some 40 times as high as that for lethals per chromosome. This has been confirmed by the more extensive experiments he carried out in the United States at a later date.

Moriwaki showed gene recombination in the male *Drosophila ananassae*, using specimens from several geographical localities in southeast Asia. Recently he has found that male crossing over is common at least in the second chromosome in these populations and that almost all males are carrying some genetic elements to cause male recombination. In general the recombination value in the male is not as high as in the female.

Cytogenetics and Human Genetics

T. H. Yosida, head of the department of cytogenetics, has studied the karyotypes of the black rat, *Rattus rattus*, which inhabits wide areas of east and southeast Asia. They have 42 somatic chromosomes, among them thirteen pairs (numbers one to thirteen) are acrocentrics of various sizes, seven pairs are small metacentrics and the rest are a large acrocentric X- and a small acrocentric Y-chromosome. Among the acrocentric group, pairs one, nine and thirteen are polymorphic, occurring in three chromosome types, namely an acrocentric homomorphic pair (a/a), a subtelocentric homomorphic pair (s/s) and an acrocentric and a subtelocentric pair (a/s). It was suggested that the acrocentric chromosomes in the three pairs are the basic karyotype and that the subtelocentric chromosomes arose from the acrocentric ones by pericentric inversion.

Yosida also found that a geographical race of *Rattus rattus* had 38 somatic chromosomes located in Oceania, Europe and America. He has suggested that this race evolved from the 42 chromosome races by "Robertsonian" type of chromosome change.

The department of human genetics (head, E. Matsunaga) is concerned with genetic epidemiology of Down's syndrome in Japan. During the past ten years data have been collected from more than 2,000 patients which has led to the estimation of rates of chromosomal mutations leading to 21-trisomy, D/G and G/G translocations, respectively, and examination of the various factors affecting them. The mutation rate for each of these chromosome aberrations was found to be essentially the same as in European populations. Among a number of factors examined, only maternal age was shown to be of aetiological significance. While it is well known that this factor is associated with the birth of children with 21-trisomy, recent examination of 102 cases of translocation Down's syndrome has indicated that maternal age also effects sporadic occurrence of these cases. The relative risk for the production of G/G apparently increases with advancing maternal age and decreases for that of D/G translocations. However, further data are needed to see whether different chromosomal mechanisms involving the 21st chromosome such as non-disjunction, isochromosome formation and centric fusion are affected by maternal age.

Table 1 A List of *Oryza* Species* Collected at the National Institute of Genetics

<i>(O. abromeitiana</i> Prod.)	<i>(O. malampuzhaensis</i> Krish. et Chand.)
<i>O. alta</i> Swallen	<i>O. meyeriana</i> Baill.
<i>O. australiensis</i> Domin	<i>O. minuta</i> Presl
<i>O. brachyantha</i> A. Chev. et Roehr.	<i>O. officinalis</i> Wall.
<i>O. breviligulata</i> A. Chev. et Roehr.	<i>O. perennis</i> Moench (including <i>O. barthii</i> and <i>O. rufipogon</i>)
<i>O. coarctata</i> Roxb.	<i>O. perrieri</i> A. Camus
<i>O. eichingeri</i> Peter	<i>O. punctata</i> Kotschy
<i>O. glaberrima</i> Steud.	<i>O. ridleyi</i> Hook.
<i>(O. grandiglumis</i> Prod.)	<i>O. sativa</i> L.
<i>O. latifolia</i> Desv.	<i>O. subulata</i> Nees (this species is now excluded from <i>Oryza</i>)
<i>O. longiglumis</i> Jansen	<i>O. tisseranti</i> A. Chev.

* Validity of species names in parentheses is doubtful.

Applied Genetics

Among the theoretical problems for plant and animal breeding, the rice plant has been most extensively investigated by I. Sakai (departmental head) and his collaborators.

A world-wide collection of *Oryza* species maintained in this institute are listed in Table 1; regrettably the two species *O. angustifolia* Hubbard and *O. schlechteri* Pilger are missing. A complete collection of wheat and relative species, however, is also kept here.

Microbial Genetics

The formation of bacterial flagella is a unique object for studying both cellular regulatory mechanisms and molecular basis of morphogenesis. The head of this department, T. Iino and his co-workers, M. Enomoto, H. Suzuki and S. Yamaguchi, have studied the mechanism of flagellar formation in *Salmonella* using a genetical approach. The results up to 1969 have been reviewed by Iino¹, but since then successful *in vitro* reconstruction of the overall process of formation of flagellar fibres from amino-acids has been achieved. It is now possible to synthesize *in vitro* flagellin molecules, that is, the monomer proteins composing flagellar filaments, from labelled amino-acids in the reaction system which contains flagellin mRNA as a primer, and allow them to be incorporated into flagellar filaments by polymerization with carrier flagellin. Purification and characterization of the different kinds of flagellin molecules can be carried out by repeated construction and dissociation of flagellar filaments followed by column-chromatography and immuno-precipitation.

This experimental system is a useful tool to investigate the process of genetic regulation of flagellar formation, and has provided information on the flagellar phase variation in *Salmonella*. In *Salmonella*, the two structure genes of flagellin, namely *H1* and *H2*, exist at different loci, and they are alternatively expressed in a clone. This phenomenon has been called "flagellar phase variation" and has been a focus of genetic investigations on bacterial flagella. The *in vitro* experiment here indicated that the alternative expression was regulated at the level of transcription on both genes. It was also shown that the inactivation of any one of the regulator genes, *fla*, resulted in the failure of transcription of the structure genes of flagellin. Polymerization of exogenous flagellin monomers was successfully carried out not only at an end of each isolated flagellar filament but also at the tips of flagella or flagellar hooks attached to cell bodies². Using this system, normal flagella were reconstituted on the cells of a straight flagellar mutant which recovered their motility lost by the mutation from normal to straight. Thus it was shown that flagellar filaments reconstituted *in vitro* are not only structurally homologous with the native ones but also functionally active.

¹ Iino, T., *Bact. Rev.*, **33**, 454 (1969).

² Iino, T., Suzuki, H., and Yamaguchi, S., *Nature New Biology*, **237**, 238 (1972).

Detection of 10–100 MeV γ -Rays from the Crab Nebula Pulsar NP 0532

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Pulsed γ -ray emission from NP 0532 has been detected up to 100 MeV. For the main pulse from 10 to 30 MeV the signal to noise is $(5-6\sigma)$. The energy spectrum of the main pulse from 1 keV to 100 MeV can be fitted by a single power law of index (-0.9) .

THE Crab pulsar NP 0532 has been detected over a wider range of the spectrum than any other celestial object. At the very high frequencies where the available detectors have poor angular resolution the pulsed nature of the radiation has permitted detection up to 3 MeV^{1,2}. Observations at even higher energies could help identify the physical process responsible for the pulsed emission and provide direct evidence for the pulsar as a source of cosmic rays.

The results of searches in the 10–100 MeV region^{3–8}, have been at best of marginal statistical significance ($2-3\sigma$) and the small peaks seen have usually been several milliseconds away from the phase observed for the optical and RF pulse. Thus only upper limits have existed for the pulsed emission above 1 MeV. Grindlay⁹ has described a positive effect above 10^{12} eV, but the conflict with another SAO result¹⁰, which shows no pulsed emission above 2×10^{11} eV, remains unresolved¹¹.

Here we present strong evidence for the existence of pulsed emission up to ~ 100 MeV. The sensitivity was improved over earlier experiments with this system^{1,2} by reducing the energy threshold to ~ 10 MeV, by operating at a float altitude of 1.2 mbar with the corresponding reduction in atmospheric background, and by using a timing system with an uncertainty of < 0.5 ms in UT.

Experimental Method

The spark chamber detection system^{12,13} has a sensitive area of 450 cm², an aperture of 60° FWHM, and a readout deadtime of 90 ms. In order to increase the conversion efficiency the original uniform thickness of 0.03 radiation length (r.l.) for the 31 spark chamber plates was increased to 0.05 r.l. for plates 16 to 27.

Because the puzzling NRL results⁵ could be explained by a preponderance of events below 20 MeV, we increased our detection efficiency in the 10–30 MeV region by using thin Al for plates 28 to 31 to reduce multiple scattering. Thus the material between the last conversion plate (No. 27) and the first trigger scintillator was 1.0 g cm⁻² of Al and Mg.

The Čerenkov counter threshold was lowered at the expense of a poorer (up/down) ratio. An on-board clock was added with a least readout of 0.125 ms that was strobed 73 μ s after the event and photographed along with the stereoscopic spark chambers views, orientation data, and housekeeping information.

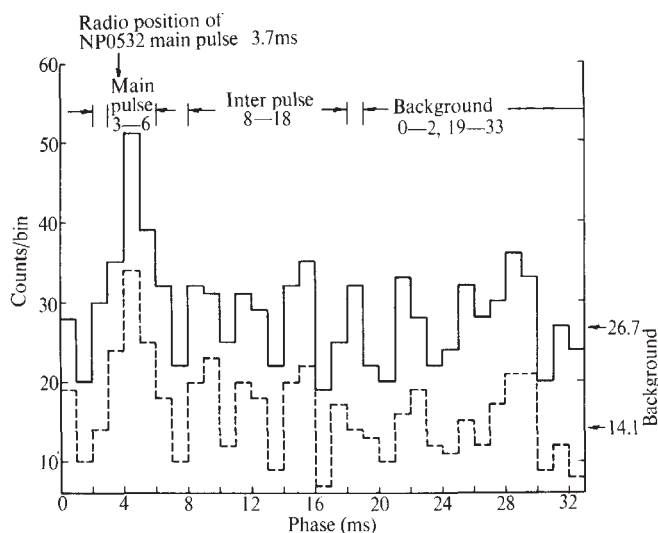


Fig. 1 Phase plot in 1 ms intervals of all events whose direction is within 15° of the Crab. —, Events originating in spark chamber plates Nos. 23–27; ---, events originating in plates Nos. 23–26.

The experiment was flown on June 26, 1971, from Palestine, Texas, on a 30 million foot³ balloon made of 0.001 cm thick polyethylene which reached a float altitude of 1.2 mbar (46.7 km), to our knowledge the highest altitude cosmic ray balloon flight ever made. Approximately one-fourth of the 128,000 pictures, recorded from 1400 to 2300 UT, were analysable γ -ray events. Because the Crab meridian transit was at 1810 UT, we obtained an excellent exposure to the Crab and this portion of the celestial sphere.

Timing Procedure

We used two independent methods of timing the individual γ -ray events. The on-board digital clock was an oven-controlled crystal oscillator which was synchronized with the ground station clock several hours before launch and read out for each

spark chamber event. The synchronization was continuously monitored during the flight by checking the on-board clock one pulse per second against the station clock one pulse per second. In turn Loran C ground wave transmission was used to check the drift of the ground station clock, which was continuously monitored to within 1 μ s. The absolute time of the one pulse per second ticks at the ground station was known to 50 μ s by using the times of emission of the Loran C signals from the Dana, Indiana, station as given in the US Naval Observatory tables.

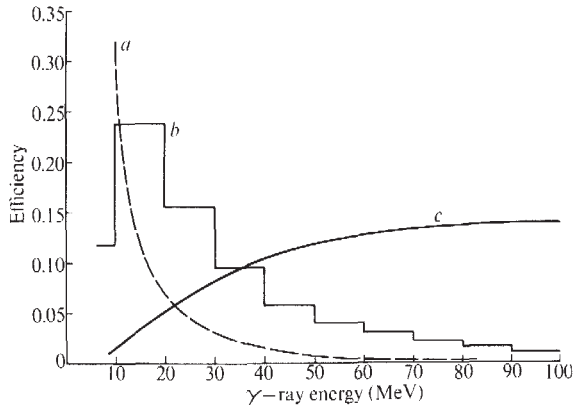


Fig. 2 Distribution of events observed in main pulse peak assuming an $E^{-2.2}$ number spectrum (arbitrary linear scale.) *a*, $E^{-2.2}$ spectrum; *b*, observations; *c*, efficiency.

Estimated errors in the timing of the events are: first, a systematic offset of ± 300 μ s, due to the instrumentation involved in comparing the on-board and ground station clocks; second, a random error of ± 200 μ s for the time of a given event, due to a combination of the 1/8 ms quantization, uncertainty in the balloon position, and electronic uncertainties.

This method was applicable until 1824 UT when the balloon drifted beyond telemetry range of the ground station. A least squares fit was made to the drift of the onboard clock before 1824 UT and used to extrapolate to 2010 UT, the end of the four hour exposure to the Crab about meridian transit. The increasing uncertainty in the extrapolation of the clock drift over the last hour of observation gives an increasing random error that approaches 0.5 ms at the end of the four hour observation. This could affect the analysis of the shape of the main pulse of NP 0532 but not its identification.

The second method for measuring the time of each event was to transmit to the ground station a fast rise time (< 10 μ s) pulse when an event triggered the spark chamber. These pulses were recorded on tape together with Loran C and WWV. So far we have not analysed the timing information on the analogue tapes and the data reported in this article come entirely from the onboard clock.

Experimental Results

The efficiency of our chamber for 10–30 MeV events is greatest for the plates nearest the trigger counter telescope where multiple scattering has the least effect. The solid line in Fig. 1 shows the phase plot in 1 ms bins of the 949 events from within 15° of the Crab direction which originated in the bottom five conversion plates (Nos. 23 to 27), taken during the optimum four hour exposure to the Crab centred on its meridian transit. Both pairs and single tracks are included. J. M. Rankin of the Arecibo Observatory kindly provided us with phase and period data for the pulsar at the given time and location of the balloon. The analysis period was always within 1 ns of the radio period by continuously updating the pulsar period over the four hour

exposure time. Optical data were not used because the Crab was near the Sun during our flight and the optical data had to be extrapolated from measurements obtained two months earlier resulting in a phase uncertainty of several ms.

The position of the principal radio pulse, corrected for dispersion, is indicated in Fig. 1 and occurs 0.3 ms before the highest peak in our histogram, which is within the absolute error of our timing analysis. Therefore we identify this peak with the main pulse of NP 0532 which has been detected in other experiments in the RF, infrared, visible, and X-ray portions of the spectrum. If the background is taken as the average level of 0–2, 19–33 ms of the phase plot the peak has a statistical significance of 5σ . The dotted line in Fig. 1 includes the same events except those originating in plate 27, or those which have only two or three sparks, which partially eliminates very low energy events, $\lesssim 10$ MeV, that would usually scatter out of the 15° cone. The main pulse is slightly more prominent in this plot of 533 events with a statistical significance of 6σ .

The 1–1.5 ms width we observe for the main pulse is consistent with the widths observed at lower frequencies^{14–16}. The intrinsic width could be somewhat less because our timing uncertainty contributes to the observed width.

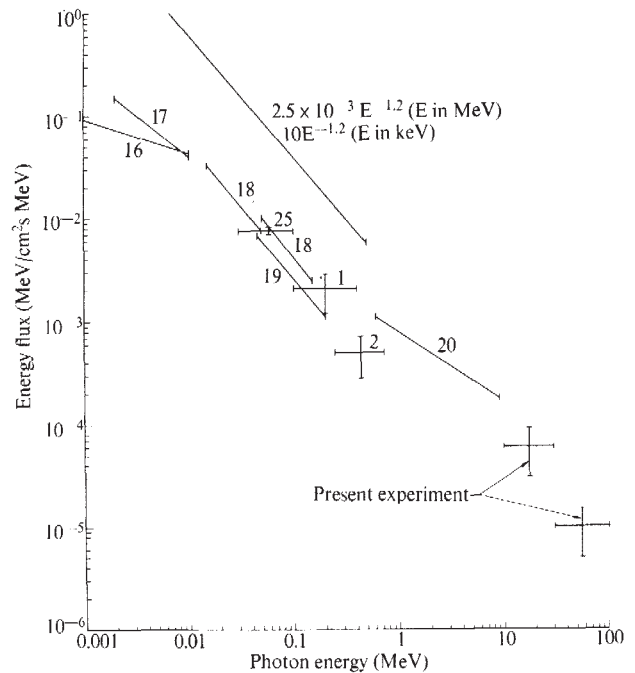


Fig. 3 Plot of time averaged flux in main pulse of NP 0532 above 1 keV.

In order to interpret the observed excess of counts between 3 and 6 ms (Fig. 1) as a flux, an assumed spectrum for the pulsar photons is required, which must be integrated over the calculated photon detection efficiency for the five bottom conversion plates (Fig. 2), and the angular resolution of the detector. The dotted curve represents the shape of an $E^{-2.2}$ differential number spectrum and the histogram gives the relative distribution of detected events against gamma ray energy which results from integrating the spectrum over the efficiency curve.

The flux values quoted for this energy range are heavily dependent on the efficiency near 10 MeV. Monte Carlo efficiencies have been used which check well with an accelerator calibration at higher energies¹². Using this calculated efficiency, we obtain an energy flux (time averaged pulsed emission) for the main pulse of

$$F_\gamma = (6 \pm 3) \times 10^{-5} \text{ MeV}/(\text{cm}^2 \text{ s MeV}) \text{ at } 20 \text{ MeV}$$

To estimate a lower bound on the flux value, one can use an efficiency curve that considers all the photons that convert in the designated plates as detected events. This gross overestimate of the detection efficiency gives a lower limit to the detected main pulse flux of

$$F_{\gamma} = 3 \times 10^{-5} \text{ MeV}/(\text{cm}^2 \text{ s MeV}) \text{ at } 20 \text{ MeV}$$

Fig. 3 shows these results plotted along with those of the other observers^{16-20,25} above 1 keV who gave sufficient data so that the time averaged flux of the main pulse of NP 0532 could be calculated. With the exception of the Bristol observation²⁰ a single spectral index of ~ -0.9 fits the main pulse flux over the five decades from 1 keV to 100 MeV.

Tests of the Identification of Pulsed Emission from NP 0532

We made several tests to ensure that the γ -radiation described in the previous section actually emanated from NP 0532 and was not due to a statistical fluctuation or spurious experimental effects. The pulsar period was varied by using a constant period, that is, taking the RF pulsar period at the beginning of the four hour exposure, but not updating it over the four hours; using the RF period decreased by 20 ns; and using the RF period increased by 20 ns. The resulting phase plot for the first test is shown in Fig. 6. Similar histograms are obtained for the other tests, and in each case there is no peak associated with the main pulse.

Table 1 NP 0532 Pulsed Energy Flux $\text{MeV}/(\text{cm}^2 \text{ s MeV})$

	Main pulse flux	Total pulsed flux
10-30 MeV	$(6 \pm 3) \times 10^{-5}$	$(9 \pm 4) \times 10^{-5}$
30-100 MeV	$(1.0 \pm 0.5) \times 10^{-5}$	$(2.5 \pm 1.5) \times 10^{-5}$

A test of the directional correlation was also made. Because our detector has a wide acceptance angle one can look for pulsed emission during the same four hours from directions having the same declination but right ascensions outside the 15° acceptance cone centred on the Crab. In Fig. 6 we show the phase plot for the 15° cone centred on $\alpha = 45^\circ$, $\delta = 22^\circ$. A similar plot is found for $\alpha = 115^\circ$, $\delta = 22^\circ$. Again there is no pulsed emission.

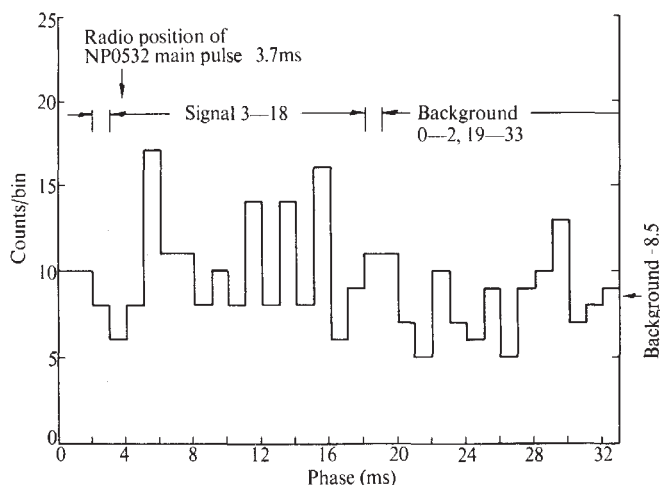


Fig. 4 Phase plot of all events within 7.5° of the Crab originating in plates 3-27.

It is somewhat surprising that we see little emission in the region of the interpulse (8-18 ms of Fig. 1), because throughout the X-ray region the ratio of interpulse to main pulse intensity is increasing with energy. The ratio of the energy in the interpulse to the energy in the main pulse is $14/47 = 0.30$ for the solid line data and $27/41 = 0.66$ for the dotted line data. Corresponding 95% confidence upper limits on the ratio are 1.2 and 1.5. From this we conclude that a significant change in the (interpulse/main pulse) ratio takes place as the photon energy is increased from several hundred keV, where the ratio is 2.3 (ref. 1), to the 10-30 MeV range where our most conservative upper limit is 1.5. The total time averaged pulsed emission for 20 MeV (3-18 ms) is

$$F_{\gamma} = (9 \pm 4) \times 10^{-5} \text{ MeV}/(\text{cm}^2 \text{ s MeV})$$

Fig. 4 shows 310 high energy ≥ 30 MeV events from within 7.5° of the Crab direction plotted versus their phase in 1 ms bins. The exposure time was the same 4 h as that for the data in Fig. 1. This bite of the photon spectrum was selected by using events from all the conversion plates (2-27). Again 0-2, 19-33 ms of the phase plot has been used to evaluate the background. The peak at 4-5 ms is 2.7σ but it is shifted by 1 ms from the position of the peak in Fig. 1 and is 1.8 ms later than the RF position. Also, there is an excess of counts of 2.5σ in the first half of the pulsar period 5-19 ms. This statistical level is of course marginal, but if the number of events above background is treated as a real signal, the corresponding flux values are as listed in Table 1. In Fig. 5 the total time average pulsed emission is plotted with the results of other experiments above 100 keV.

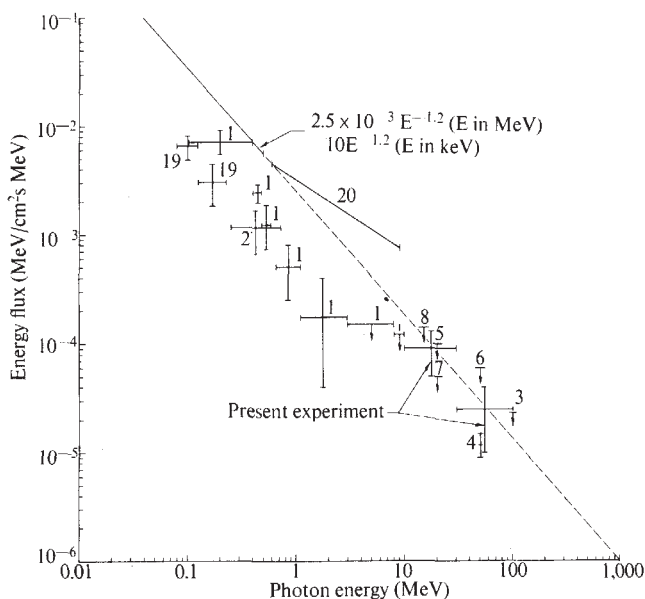


Fig. 5 Plot of time averaged pulsed flux from NP 0532, that is, from beginning of main pulse to end of interpulse.

In summary, our identification of the peak at 3-6 ms in Fig. 1 as γ -radiation from the main pulse of NP 0532 is based on first, the occurrence of a 5-6 σ peak within 1 ms of the phase of the main pulse observed at RF, visible and X-ray frequencies; second, a width similar to that observed at lower frequencies; third, the disappearance of the peak when the NP 0532 period is not updated over the four hour exposure; fourth, the disappearance of the peak when a slightly different period is used; and fifth, the absence of a peak from neighbouring areas of the sky observed during the same four hour exposure.

Discussion of Mechanism Required

Although there have been many theoretical discussions of the basic mechanism by which the rotating neutron star emits its characteristic pulsed radiation, as far as we are aware Sturrock²¹ is the only one who makes a quantitative prediction of the flux to be expected above 1 MeV. McBreen²², Pollack *et al.*²³ and Stecker and Tsuruta²⁴ have discussed the possibility of a cutoff in the γ -ray spectrum arising from the production of electron-positron pairs from the photon-photon interaction of γ -rays with the observed X-rays. Pollack *et al.* place this cutoff at 1 MeV if the interaction takes place near the surface of the neutron star, but Stecker and Tsuruta state it is at 500 MeV if the directional beaming of the radiation is properly taken into account.

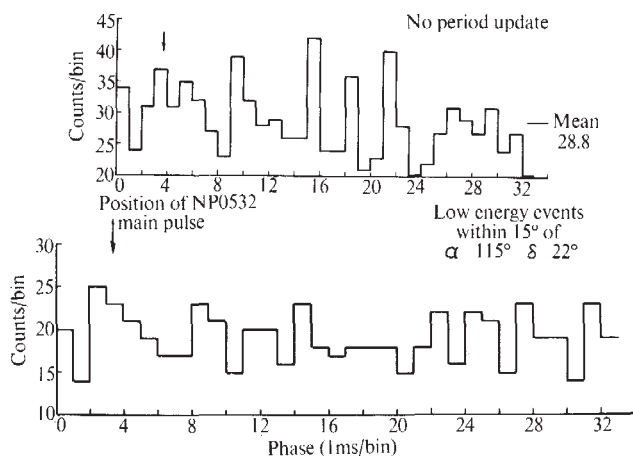


Fig. 6 Phase plots comparable to Fig. 2 except that the pulsar period was kept constant during the four hour exposure and the acceptance cone did not include the Crab direction.

The value measured in this experiment for the time averaged flux of the main pulse at 20 MeV of $(6 \pm 3) \times 10^{-5} \gamma \text{ cm}^{-2} \text{ s}^{-1}$ agrees closely with that predicted by Sturrock for $B=10^{12.0}$ gauss assuming the radiation at 20 MeV is synchrotron radiation from the electron-positron pairs produced by higher energy photons interacting with the magnetic field. The higher energy γ -rays were in turn the result of curvature radiation from high energy protons emanating from a proton polar zone (PPZ). But this mechanism predicts a spectral index of -0.5 whereas the experimental results from 1 keV to 100 MeV show that the index is ~ -0.9 . The latter value is close to the predicted index for curvature radiation, so possibly the observed radiation is a combination of synchrotron and curvature radiation.

Our data in conjunction with the SAO results^{10,11} above 10^{11} eV show that the energy spectrum for the main pulse becomes steeper between 100 MeV and 10^{11} eV. Extrapolating the -0.9 spectrum index of Fig. 3 to 2×10^{11} eV predicts a flux of $1 \times 10^{-9} \text{ MeV}/(\text{cm}^2 \text{ s MeV})$ whereas Fazio *et al.*¹¹ set an upper limit of $2 \times 10^{-11} \gamma \text{ cm}^{-2} \text{ s}^{-1}$. Similarly at 6.8×10^{11} eV the power law extrapolation predicts $4 \times 10^{-10} \text{ MeV}/(\text{cm}^2 \text{ s MeV})$. Grindlay's⁹ integral main pulse flux above this energy is $3 \times 10^{-12} \gamma \text{ cm}^{-2} \text{ s}^{-1}$. Thus the spectral index must increase by almost an order of magnitude between 100 MeV and 10^{11} eV in contrast to its constancy between 1 keV and 100 MeV. If this is actually the cutoff predicted by the photon-photon interaction, its location is nearest the prediction of Stecker and Tsuruta²⁴.

The pulsed energy flux in the interval 10–30 MeV is $\sim 1.5 \text{ keV cm}^{-2} \text{ s}^{-1}$, comparable to that observed at <100 keV and at (0.1–1.0) MeV (ref. 1), and very close to the value predicted by the expression for the time-independent energy flux for the

Crab Nebula valid above 1 keV, $F(E)=10 E^{-1.2} \text{ keV}/(\text{cm}^2 \text{ s keV})$. Thus our result is consistent with all the emission at this energy being in the pulsed mode.

In principle this experiment has the same intrinsic timing accuracy as one has for measuring the arrival of individual photons from the optical pulsar, the only complication being the accurate location and drift of the balloon. Accuracy in UT of <0.1 ms should be obtainable in future experiments. Larger area detectors will permit improved statistics so that the detailed shape of the γ -ray peak can be compared to that observed at lower energies and indeed compared between 10–30 and 30–100 MeV. One very important experiment for the future is to measure accurately the phase of the main pulse at γ -ray energies to determine if there is any shift from the optical and X-ray positions, as might be expected if the one originates near the surface of the neutron star and the other at the speed-of-light cylinder. The 1 ms shift between 20 and 70 MeV observed here is probably a result of poor statistics, but any future observations should have 0.1 ms UT accuracy to investigate further such possible effects.

We thank J. Panettieri and R. Schreiner for technical help; M. Nazaretz and J. Vogel for assistance with the flights; Dr J. Staib for some of the calculations; Dr H. Helmken for optical NP 0532 data; C. Conoboy, M. Horng, L. Rubin, M. Samuels, L. Satz, V. Sethi, Y. Strauss, N. Varma, D. Laba, M. Nash and M. Reardon for scanning the film; and the personnel of the NCAR Balloon Base, Palestine, Texas, for conducting the flights. The work was supported in part by grants from the National Science Foundation, the Australian Research Grants Committee and the Royal Australian Air Force.

Received August 25, 1972.

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Genes Coding for Polysomal 9S RNA of Sea Urchins: Conservation and Divergence

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The DNA sequences coding for the individual major subfractions of the putative histone mRNAs are all 1,200-fold reiterated and are contained in a "cryptic" density satellite in *Psammechinus* DNA. While random mutational drift cannot be detected in the 9S mRNA coding sequences within the species, it is very much in evidence during the evolution of two related sea urchin species.

In the rapid development of the sea urchin embryo from the 16-cell to early blastula stage the newly synthesized 9S RNA

associated with small polysomes¹⁻³ most probably codes for histone proteins⁴⁻⁷. 9S RNA is complementary to repetitive DNA of *Psammechinus milaris* as shown by hybridization of 9S RNA to DNA in large excess⁸. In these experiments hybridization occurred over several log units of the DNA *C₀t*-curve and some hybrids were of poor quality, which suggests either sequence heterogeneity intrinsic to the 9S RNA or contamination by other RNAs.

To distinguish between these possibilities, we have further purified and separated the polysomal 9S RNA into individual constituents by gel-electrophoresis and then hybridized them with DNA. Here we show that 9S RNA from two sea urchins can be fractionated into at least three distinct components which all hybridize to a "cryptic" DNA satellite. We demonstrate that 9S DNA complements within species show no measurable sequence diversity, but diverge rapidly between species, presumably, as a consequence of random mutation drift amongst synonymous codons.

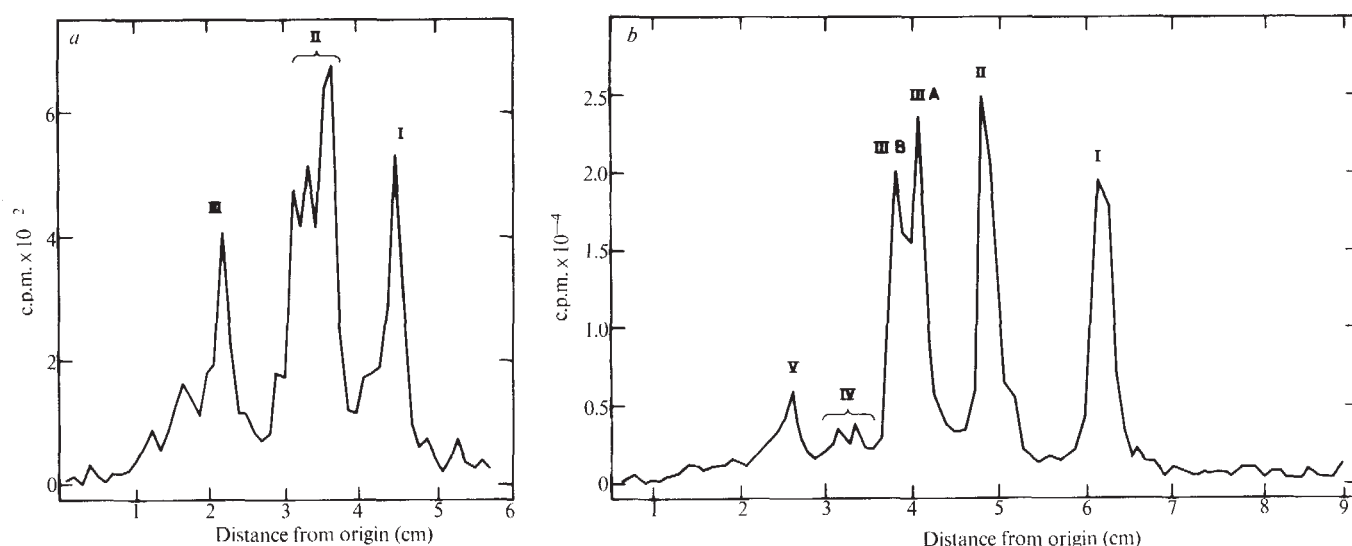


Fig. 1. *Paracentrotus* (a) and *Psammechinus* (b) 9S RNA fractionated on polyacrylamide gels: 1–2 g sea urchin embryos were incubated in 50 ml. sea water containing 4–5 mCi of ³H-uridine. Labelling periods were from 3.75–7.75 h after fertilization for *Paracentrotus* and 3.5–6 h for *Psammechinus*. Preparation of polysomal pellets, extraction with phenol and chloroform, and separation of the 9S peak by sucrose gradient centrifugation were carried out essentially by the methods of Kedes and Birnstiel⁹. The 9S peak, containing 1/4–1/3 of the counts incorporated into the total polysomal RNA, was precipitated in ethanol and resuspended in 1 ml. of distilled water containing 0.5% SDS. Aliquots of these 9S preparations were applied to 6% acrylamide gels prepared in the 36 mM phosphate buffer of Loening²⁴ and run with 0.2% SDS. 11 cm gels were used, and the runs were at 1.5 mA/gel for 4.5 h (*Paracentrotus*) and 1.8 mA/gel for 5.5 h (*Psammechinus*).

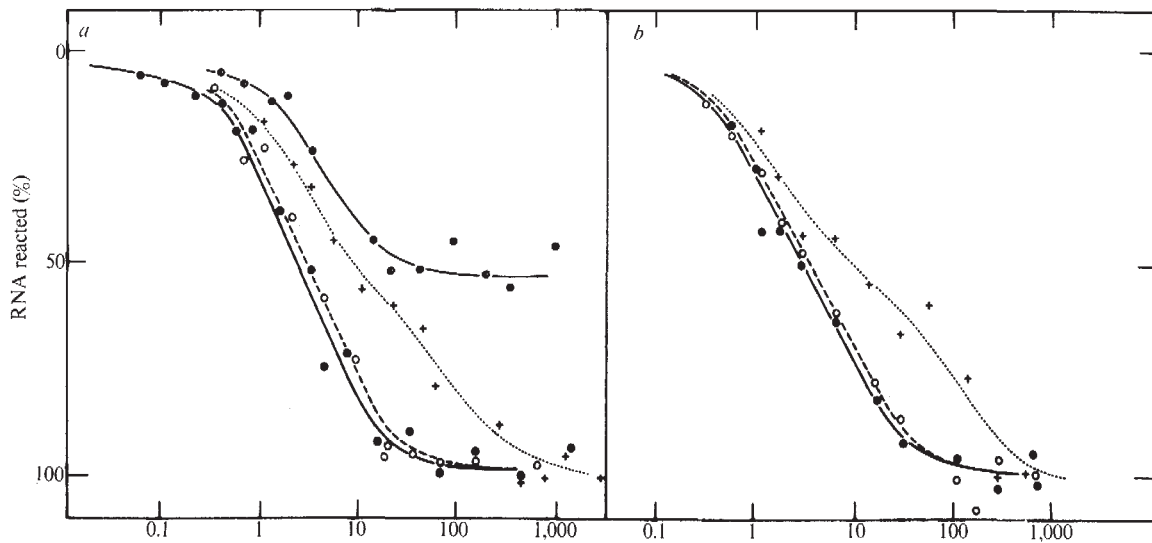


Fig. 2 Hybridization of 9S subfractions in conditions of DNA excess: a solution of *Psammechinus* DNA at 3–6 mg ml.⁻¹ in 1 × SSC containing 0.25% SDS was heat denatured (100° C, 5 min) and then placed at 70° C. Immediately an aliquot containing approximate 10⁴ c.p.m. of a particular RNA subfraction (prepared by eluting individual gel slices with high salt buffers) (0.6 M Li-acetate; 0.5% SDS; pH 6.0, Loening, U. E., unpublished work) was added. At various times, aliquots were removed and added to 2 ml. of 1 × SSC at 0° C. The sample was split equally, half being treated with 5 µg pancreatic RNAase and 2 U.T.₁ RNAase for 15 min at 37° C. The percentage of input RNA which was RNAase resistant was calculated for each time point. Zero time samples were prepared by heating an aliquot of the reaction mixture to 100° C for 2 min and quickly adding it to 2 ml. of 1 × SSC at 0° C. Zero time values were 2–8% of the input RNA counts. All reactions proceeded to 72–90% of the counts in RNAase resistant form. “I–V” refer to *Psammechinus* RNA fractions and “I heterologous” refers to hybridization of *Psammechinus* fractions I to *Paracentrotus* DNA. Each reaction with *Psammechinus* DNA was normalized to 100% final reaction after subtracting the zero time for purposes of comparison C_{0t} (ref. 10). The values for *Paracentrotus* fraction I have been normalized by comparison to the homologous reaction. Other heterologous reactions gave similar curves (compare, Table 2). (a, + ... +, Total 9S; ●—●, I; ○—○, II; ●—●, I, heterologous. b, ●—●, III A; ○—○, III B; + ... +, IV+V.

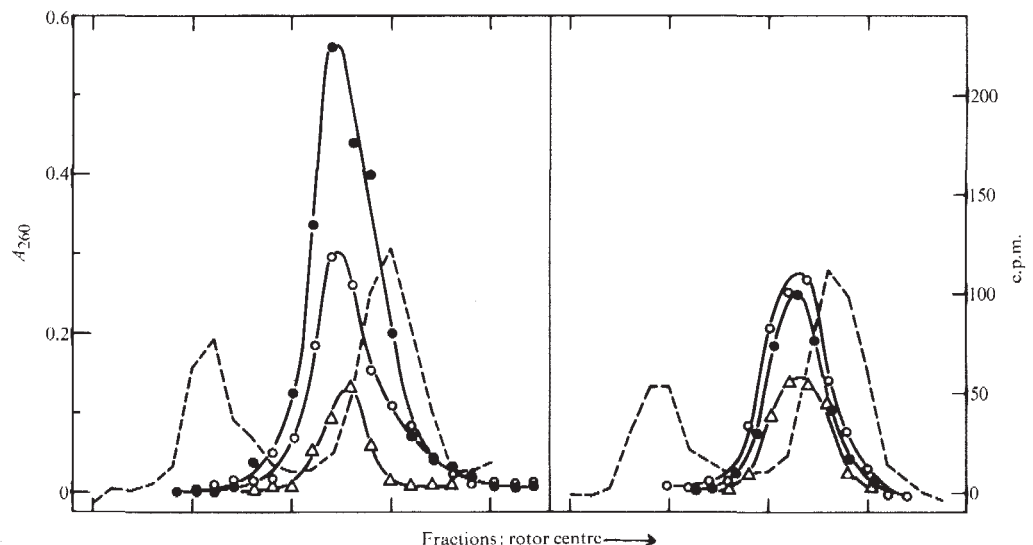
The 9S polysomal RNA labelled by incubation of cleaving embryos of *Paracentrotus lividus* and *P. miliaris* with ³H-uridine (50–100 µCi ml.⁻¹) can be separated by electrophoresis through 6% polyacrylamide gels into at least three components (Fig. 1). The specific activity of the RNA from both species was estimated to be of the order of 10⁶ c.p.m. µg⁻¹.

1,200-fold Reiteration of 9S Complements

We annealed each RNA component containing approximately 10⁴ c.p.m. *P. miliaris* with a large excess of sonicated DNA

(3–6 mg ml.⁻¹) according to the protocol of Melli *et al.*¹⁰, with minor modifications (*cf.* Fig. 2). The RNA trace curves for fractions I, II, IIIa and IIIb all exhibited a C_{0t} of 2–3. We do not consider the minor differences observed in C_{0t} from the various RNA fractions to be significant. Melli *et al.*¹⁰, have determined that the *E. coli* cRNA trace-curve has a C_{0t} of 15.9 under similar assay conditions. Using their formula for the calculation of reiteration frequency, and assuming an analytical complexity of sea urchin DNA of 5 × 10¹¹ dalton, we calculate that in this species the 9S DNA are about 1,200-fold repeated, in *Paracentrotus* (not shown) about 400-fold repeated.

Fig. 3 Hybridization of the individual RNA fraction to CsCl density fractions of *Psammechinus* DNA. *Psammechinus* DNA (40 µg) of high molecular weight (4×10^7) was centrifuged to equilibrium on a CsCl density gradient ($S_{average} = 1.720$, 25° C, 42,000 r.p.m. for 32 h in a ‘MSE’ 10 × 10 rotor), ten-drop fractions collected and the DNA was bound to millipore filters as described^{9,22}. 2 × 10⁴ c.p.m. of each RNA fraction was hybridized to the DNA of CsCl density fractions in 1 × SSC 70° C for 3 h and washed as described²³. *M. luteus* DNA. a, ○—○, I; ●—●, III A+B; △—△, IV. ---, b, ○—○, Total 9S; ●—●, II; △—△, V.



The slopes of the individual trace curves for components I-IV are those of ideal second order reactions. By contrast the trace curves obtained with total unfractionated 9S RNA, or with the combined fractions IV and V, reveal RNA species which anneal to both highly and poorly reiterated fractions.

Clustering of the 9S DNA Sequences on Chromosomal DNA

We have found that all *Psammechinus* 9S subfractions hybridize exclusively to the DNA of high density identified by Kedes and Birnstiel⁹ with unfractionated 9S RNA (Fig. 3).

9S RNA subfractions, once purified by gel electrophoresis, do not generate poor hybrids and that the hybridization reaction is very specific. The T_m corresponds to a GC content of 54%¹²⁻¹⁴ which closely agrees with the estimated GC content of the 9S DNA⁹. Therefore, no sequence heterogeneity can be shown for the 9S DNA complements. If significant heterogeneity did exist, the T_m would be depressed and a less sharp melting profile would be expected.

The nearly complete reaction (72-88%) of 9S RNA with DNA in excess and the fact that only a small portion of RNA is sensitive to RNAase after hybridization to DNA in RNA excess (Table 1) indicates that once nucleated with complementary DNA, RNA sequences anneal nearly quantitatively

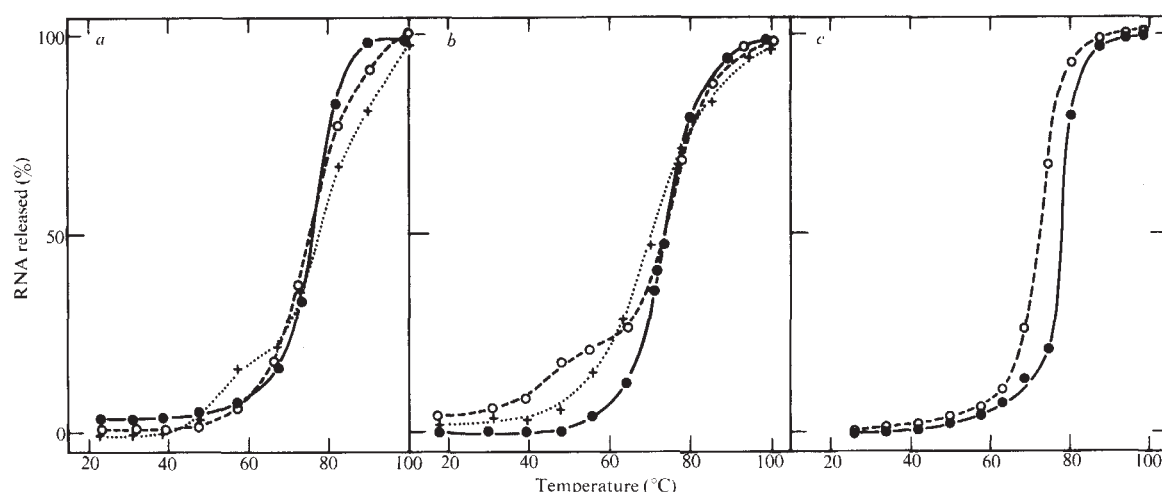


Fig. 4 Melting of RNA/DNA hybrids prepared with *Psammechinus* 9S RNA subfractions. Hybrids were formed with DNA immobilized on filters by the technique of Gillespie and Spiegelman²². Filters contained 10 μ g DNA and RNA concentration was 6×10^4 c.p.m. ml.⁻¹. Homologous reaction. Conditions used were $6 \times$ SSC, 50% formamide at 50° C for 1 h. Filters were then washed, treated with RNAase, $2 \times$ SSC, 0.1% diethylpyrocarbonate and $0.1 \times$ SSC. Melting was done in increments of 5-8° C with a 5 min equilibration with 1 ml. of $0.1 \times$ SSC at each temperature. The released RNA was precipitated with TCA and counted. Cumulative acid precipitable counts are plotted here against temperature. a, + . . . +, Total 9S; ●—●, I; ○—○, II; b, ●—●, III; ○—○, IV; + . . . +, c, Melts of hybrids formed with 9S RNA subfractions of *Psammechinus* and either *Psammechinus* or *Paracentrotus* DNA. Hybrids were formed by reacting to approximately 10^4 c.p.m. of an individual RNA subfraction to 25 μ g DNA immobilized on filters in 0.5 ml. $1 \times$ SSC at 70° C for 3 h. Each reaction mixture contained three filters containing *Psammechinus* DNA and 5 *Paracentrotus* DNA. ○—○, Melts of cross-species hybrids (*Paracentrotus* DNA); ●—●, homologous hybrids (*Psammechinus* DNA). No counts were left on filters after 5 min treatment at 100° C. Temperatures noted in the figure at the T_m s for the respective hybrids.

Hybridization of fractions IV and V was relatively inefficient, possibly because these fractions are still contaminated by other RNA. The similarity of reiterated, the well defined hybridization of all sea urchin 9S subfractions to a "cryptic" DNA satellite of unique density and hybridization *in situ* of 9S RNA to a single region of the *Drosophila* chromosome II¹¹, supports the hypothesis that the various 9S DNA sequences are clustered and tandemly arranged with spacer DNA⁸ on chromosomal DNA.

Within-species Homogeneity of 9S Sequences

RNA/DNA hybrids of fractions I-IIIb all melt in 0.015 M NaCl; 0.0015 M Na-citrate, pH 7.2 with a T_m at 75-76° (Fig. 4), but fraction IV as well as total 9S RNA and possibly fraction V also contain low melting components. The melting curves of the hybrids from fractions I and II were identical to those shown in Fig. 3 when these species were annealed at saturating RNA concentrations to total DNA. This shows that the major

to DNA. This is a further indication that the degree of sequence heterogeneity is negligible.

Within-species Conservation of 9S Sequences

It is interesting to compare these findings to the degree of sequence heterogeneity which would be created by random mutational drift, but would still be compatible with the proper coding properties of these genes. Because of the degeneracy of the genetic code, many base substitutions do not result in a change in the amino-acid sequence of the protein. It has been calculated¹⁵ that 34% of base substitutions by GA and CT transitions and 23% of all single base substitutions occurring with equal frequency yield synonymous codons. There is therefore wide scope for sequence variation without affecting the primary structure of proteins¹⁶.

To demonstrate the effect of such heterogeneity on RNA/DNA hybridization, in collaboration with Professor A. Robertson (Edinburgh), we have simulated the hybridization

reaction in a computer. Since 9S polysomal RNA probably codes for histones we thought it appropriate to consider the sequence divergence of genes coding for histone IV proteins¹⁷.

Table 1 Hybrid Resistance to RNAase

Experiment	C.p.m./filter		Resistance %
	– RNAase	+ RNAase	
I	557	548	98.2
II	424	379	89.4

A reconstructed *Psammechinus* 9S RNA fraction was prepared by combining equal amounts of counts of Fractions I–IIIb. Total input for Experiment I was 2×10^4 c.p.m. Experiment II, 1.5×10^4 c.p.m. Filters each containing 25 μ g DNA were used for each experiment. Hybridization was performed in $6 \times$ SSC, 50% formamide at T_{opt} of 52° (I) or 50° C (II) for 1 h. 0.25% SDS was present in Experiment II and absent in Experiment I. Washing was exactly as Birnstiel *et al.*²³ except that for each experiment ten filters were treated with 10 μ g ml.⁻¹ pancreatic RNAase while ten filters were washed an extra time in $2 \times$ SSC.

We found that degenerate isocoding genes and their primary products would form RNA/DNA hybrids of poor quality, containing after completion of the reaction predominantly short matched regions attached to long unmatched tails, and because of the extensive randomization of the sequences, the DNA specifying histone IV would probably behave as unique DNA^{16,18}. By contrast, no sequence heterogeneity can be found experimentally (see above) and the 9S DNA is highly repetitive. There is obviously a large discrepancy between the heterogeneity which might be tolerated by the organisms and that actually found in the experiment. We therefore conclude that “corrective” mechanisms must intervene, to conserve and maintain the 9S RNA coding sequences within the species.

9S RNA Sequence Homologies of Closely Related Species

Kedes and Birnstiel⁹ and McCarthy and Farquhar¹⁹ showed that 9S RNA of sea urchins hybridized at low levels to DNA of a wide range of species. This might have arisen from either sequence divergence or from poor reiteration of the 9S coding sequences in the heterologous DNA. To test conservation of 9S RNA during evolution of sea urchin species, we have hybridized 9S RNA fractions of *Paracentrotus* to DNA of *Psammechinus*, and 9S RNA from *Psammechinus* to DNA of *Paracentrotus*. Only about half of the *Psammechinus* fraction I RNA, when compared to homologous controls, anneals to *Paracentrotus* DNA (Fig. 2). Table 2 gives the results of five reciprocal crosses of RNA with heterologous DNA. Forty–fifty percent of the various purified RNA molecules hybridize to heterologous DNA, while the remainder has diverged sufficiently to be no longer able to anneal. The degree of divergence is similar for all 9S RNA subfractions studied. We conclude that while random mutations in nucleotide sequences cannot be detected within the species, it is very much in evidence during the evolution of the species.

Rate of Evolution of 9S RNA Coding Sequences

Both genera of sea urchins used, *Psammechinus* and *Paracentrotus* are said to be found first in the Miocene 15 to 35 m.y. ago. Hybridization in DNA excess, represents a sensitive instrument to detect sequence divergence between RNA molecules of different species. As the minimal stable length of the hybrids operating in DNA excess hybridizations using RNAase is unknown the corresponding percent base substitu-

tions cannot be calculated from these results. We have instead measured the melting temperatures of RNA/DNA hybrids bound to membrane filters which had not been treated with RNAase. From Fig. 4 and Table 2 it may be seen that hetero-

Table 2 Divergence of 9S Coding Sequences

RNA	% Reaction with heterologous DNA	ΔT_m
<i>Psammechinus</i> I	36	5
II	38	4.5
III	40	5.5
<i>paracentrotus</i> I	30	—
II	32	—

Homologous reactions 72–88%.

Heterologous reactions were carried out as in Fig. 1 (for example, I “heterologous”) to a C_0t of at least 1,000. At this C_0t -value 32–40% of the heterologous RNA became resistant to RNAase, while in the homologous reaction about 80% of the RNA reacted. T_m were determined from RNA excess hybridization experiments as shown in Fig. 4c.

logous hybrids melt some 5° C lower than homologous hybrids. According to recent determinations¹⁹ 1% mismatching depresses the T_m by about 1.6° C, so we calculate that the 9S RNA sequences between *Psammechinus* and *Paracentrotus* have diverged by some 3%*. From this we can calculate that the rate of mutation within 9S coding sequences is of the order of $3\text{--}6 \times 10^{-9}$ substitutions per codon per year. This is a quarter of the rate estimated for the evolution of unique DNA in vertebrates²⁰ and corresponds to the theoretical expectations. In genes coding for conservative proteins such as histones only about one in four base substitutions lead to synonymous codons and these would be fixed in evolution, while the remaining three out of four would alter the primary structure and would be discriminated against by natural selection.

Received June 9; revised September 27, 1972.

* From the data of Laird *et al.*²¹, a base substitution of 7% could have been obtained.

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LETTERS TO NATURE

PHYSICAL SCIENCES

Pulsar Associated with the Supernova Remnant IC 443

DURING the period July 26 to September 21, 1972, the Jodrell Bank Mark IA radio telescope has been engaged in a systematic search for pulsars at a frequency of 408 MHz. The technique is that used by Davies, Large and Pickwick¹ in 1970, but adapted in a way that allows the analysis to be carried out in real time on the Argus data processing computer.

A total of 3,280 beam areas in a region based on the galactic plane were observed (approximately 600 of them more than once where the presence of a pulsar was suspected from the first observation) for a period of about 11 min, and the result analysed for periods in the range 0.16 to 1.45 s, although pulsars outside this period range also produce detectable results.

In addition to many of the known pulsars in the area covered, eighteen new pulsars were discovered, their characteristics being given in Table 1. These data are obtained with a normal pulsar observation system, which allows more precise measurements to be made of period, position, pulse shape and flux density. The dispersion measures are obtained from two bandwidths separated by 4 MHz at 408 MHz. The fluxes are obtained in most cases from about 12 min observation, and hence are subject to some uncertainty due to scintillation, particularly in the cases of pulsars with low dispersion measures. PSR 0355+54 was discovered independently by Taylor, Huguenin and Manchester².

Fig. 1 presents the best available data on the shapes of the pulses from the new pulsars. The sources 1718-32 and 1826-17 both show strong indications of pulse broadening due to multiple scattering in the interstellar medium.

PSR 0611+22 lies about 0.6° from the centre of the supernova remnant IC 443, whose diameter is 0.7° . The position

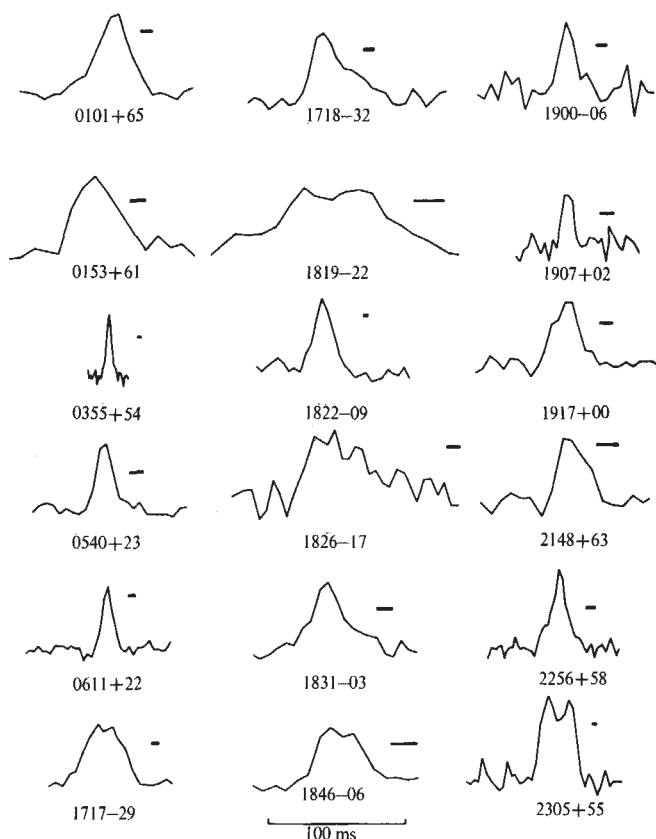


Fig. 1 The pulse profiles of the eighteen new pulsars obtained by integrating the total intensity (Stokes parameter I) for between 10 min and 1 h. The thick horizontal bars associated with each source represent the instrumental resolution. The time scale for all the profiles is the same, and is indicated by the 100 ms bar at the bottom of the figure.

Table 1 Characteristics of Eighteen New Pulsars

PSR	RA			$\pm s$	DEC			L deg.	B deg.	Period		DM pc. cm ⁻³	Flux density 10 ⁻²⁶ W m ⁻² Hz ⁻¹
	h	min	s		deg.	min	$\pm$ min			s	$\pm \mu s$		
0105+65	01	05	00	60	+65	50	7	124.6	+3.3	1.283651	1	30 $\pm$ 10	0.018
0153+61	01	53	00	60	+61	55	10	130.5	+0.2	2.351615	1	60 $\pm$ 30	0.013
0355+54	03	55	00	40	+54	13	8	148.1	+0.9	0.156380	1	58 $\pm$ 03	0.056
0540+23	05	40	10	40	+23	30	10	184.4	-3.3	0.245964	1	72 $\pm$ 09	0.030
0611+22	06	11	03	15	+22	35	5	188.7	+2.4	0.334918	1	99 $\pm$ 05	0.048
1717-29	17	17	10	40	-29	32	10	356.5	+4.3	0.620449	1	45 $\pm$ 10	0.030
1718-32	17	18	40	40	-32	05	10	354.5	+2.5	0.477154	1	120 $\pm$ 12	0.095
1819-22	18	19	50	60	-22	53	8	9.4	-4.3	1.874398	7	140 $\pm$ 30	0.022
1822-09	18	22	40	40	-09	36	7	21.4	+1.3	0.768948	1	21 $\pm$ 08	0.025
1826-17	18	26	15	60	-17	54	10	14.6	-3.3	0.307128	2	210 $\pm$ 20	0.085
1831-03	18	31	00	40	-03	40	10	27.7	+2.3	0.686675	1	230 $\pm$ 20	0.067
1846-06	18	46	07	30	-06	43	7	26.7	-2.4	1.451323	9	152 $\pm$ 08	0.031
1900-06	19	00	30	40	-06	35	10	28.5	-5.6	0.431885	1	180 $\pm$ 20	0.016
1907+02	19	07	20	40	+02	56	11	37.7	-2.7	0.494914	1	190 $\pm$ 20	0.015
1917+00	19	17	15	40	+00	18	8	36.5	-6.1	1.272254	5	85 $\pm$ 10	0.034
2148+63	21	48	00	40	+63	10	7	104.1	+7.4	0.380142	1	125 $\pm$ 20	0.025
2256+58	22	56	30	60	+58	50	7	108.9	-0.7	0.368241	1	148 $\pm$ 06	0.042
2305+55	23	05	00	60	+55	26	10	108.6	-4.2	0.475068	1	45 $\pm$ 08	0.023

Table 2 Period of PSR 0611+22

Date	Barycentric period (s)
August 28, 1972	0.33491817 ± 8
October 12, 1972	0.33491850 ± 4

and period of the pulsar were therefore measured with greater precision than the other new pulsars, and the period measured on August 28 and October 12, 1972, is given in Table 2. The uncertainty in the period due to the barycentric correction is less than 10^{-8} s. The period has therefore increased by $0.33 \mu\text{s} \pm 0.09 \mu\text{s}$ in 45 days, giving a value of $P/\dot{P}$ of 125,000 yr. This can be compared with the age of IC 443 estimated by Minkowski² of 65,000 yr. Milne³ gives a distance of 1.4 kpc for IC 443, compared with 1.7 kpc for the Crab Nebula, which is 10° distant in the sky. The dispersion measure for PSR 0611+22 is 99 pc cm^{-3} , and for the Crab Nebula 57 pc cm^{-3} . In the neighbourhood of IC 443 there is a large HII region, which may contribute considerably to the dispersion measure of PSR 0611+22. Therefore the distance inferred from the dispersion measure is not discordant with that quoted for IC 443, and in view of the period measurements, the association of the pulsar with the supernova remnant seems clear. Assuming a distance of 1.4 kpc and a time of 125,000 yr, the pulsar's velocity normal to the line of sight is 110 km s^{-1} .

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Received October 11, 1972.

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MWC 349, a New Radio Star

FURTHER examination of the Westerbork 1,415 MHz observations of the Cygnus X-3 region¹ revealed the presence of a radio source at the position of the peculiar emission-line star MWC 349.

The source, with a flux density of 0.060 ± 0.007 flux units, is located at

$$\alpha(1950) = 20 \text{ h } 30 \text{ m } 56.8 \text{ s} \pm 0.2 \text{ s} \\ \delta(1950) = +40^\circ 29' 20.9'' \pm 2.5''$$

the rather large uncertainties being due to the distance of more than half a degree from the field centre. An upper limit of 20 arc s can be placed on the angular size of the source.

Comparison with the position of MWC 349,

$$\alpha(1950) = 20 \text{ h } 30 \text{ m } 56.82 \text{ s} \pm 0.01 \text{ s} \\ \delta(1950) = +40^\circ 29' 21.1'' \pm 0.1''$$

as measured from a Kodak 103a-O plate taken with the Leiden 33 cm refractor on September 30, 1972, strongly suggests that the radio emission is associated with this star. Certainly the probability of a chance coincidence between a 0.06 f.u. background source and a peculiar object like MWC 349 must be very low.

The star, which is identified on a photograph in the paper by Herbig and Mendoza², appears to be an object of exceptional interest. In the Mount Wilson Catalogue³ it is listed as a Bep star of photographic magnitude 13.2. Swings and Struve⁴ found it to be fainter than the 14th magnitude, and on the Leiden plate it appears as a slightly elongated image of magnitude ~ 15.5 . The elongation is probably caused by the presence of a faint companion approximately 2 arc s north preceding⁵.

Swings and Struve consider MWC 349 to be an early B-type object related to the symbiotic stars; they identified bright emission lines of H, He I, [O I], [N II], Fe II, and [Fe III] in its spectrum, and state that "the general intensity distribution in the continuous spectrum is similar to that of a late M star, but no late type absorption feature is apparent". Further, they find spectroscopic evidence for a tremendous absorption, probably of the order of 10 magnitudes. The star also occurs in Ackermann's catalogue of infrared objects in Cygnus⁶ (star 78-0-94). On the basis of an objective-prism spectrum showing a near-infrared band of CN, he classifies MWC 349 as a carbon star, and from photographic photometry on the PSS prints he derives $B = 14.5$, $B - R_K = 5.5$; corresponding to $V \approx 11$, $B - V \approx 3.0$. These data are consistent with Swings and Struve's result, for, assuming a normal reddening law ($R = 3$), the colour index is that of an early-type object with $A_V \approx 9$. The presence of the CN band supports the picture of a symbiotic star. Finally, MWC 349 has been reported to show an infrared excess by Geisel⁷. She links this excess radiation to circumstellar material ejected from the star.

An obvious interpretation of all the available data is that we are dealing with a binary system comprising a hot and a cool component embedded in a circumstellar cloud of gas and dust. Judging from its position in the colour-magnitude diagram it may belong to the heavily obscured Cyg OB2 association centred about half a degree to the north. Membership of Cyg OB2 would imply a distance of 2.1 kpc (ref. 8) and an absolute visual magnitude of about -10.0 , placing MWC 349 among the intrinsically brightest stars known.

Clearly a detailed spectroscopic and photometric analysis is necessary to determine the exact nature of the object. If the observed radio emission is thermal bremsstrahlung then the predicted H α flux is much smaller than that corresponding to the observed V magnitude. In this case an accurate measurement of the H α flux would yield a direct determination of the extinction at $\lambda 6,563$ and therefore may be of prime interest.

The Westerbork Radio Observatory is operated by the Netherlands Foundation for Radio Astronomy with the financial support of the Netherlands Organization for the Advancement of Pure Research (ZWO).

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The 8 to 13 μm Spectrum of Jupiter

THE spectrum of Jupiter in the wavelength range 8 to 13 μm is dominated by planetary thermal radiation and can give information on the thermal structure of the atmosphere. Spectra in this wavelength range have been published by Low¹ and by Gillet, Low and Stein². The latter, with resolution $\Delta\lambda/\lambda \sim 0.02$, gives a hint of the absorption structure of the ν_2 band of NH_3 , and the high brightness temperature observed in the region 7.8 to 8.4 μm has been interpreted as due to CH_4 emission from a temperature inversion in the atmosphere of Jupiter. Encrénaz³ has computed the expected Jovian infrared spectrum for a number of model atmospheres, with and without temperature inversion. Here we present

observations with resolution $\Delta\lambda/\lambda=0.007$ in which details of the ν_2 band of NH_3 are seen in absorption, resembling the model atmosphere of Encrenaz with monotonically decreasing temperature.

The observations were made using the 60-inch Izaña, Tenerife infrared telescope on two nights in May 1972. The spectrophotometer consisted of a grating mounted in a modified "Czerny-Turner" configuration and driven by a stepping motor, and the radiation was detected by a gallium doped germanium bolometer operated at a temperature of 1.8 K. Resolution was defined by an aperture in front of a KBr Fabry lens which imaged the input optics on to the bolometer. The aperture, lens and filters defining the $10\text{ }\mu\text{m}$ region were in thermal contact with the base of the cryostat at 1.8 K.

A small mirror driven by a 12.5 Hz square wave produced two fields of view separated by the diameter of Jupiter (42 arc s) and, with the central 18 arc s of the planet contained in one beam, a complete scan of the spectrum from 8–13.5 μm was made involving 140 steps of the grating. The integrated response for each of these was recorded on magnetic tape. This procedure was repeated with the central region of the planet positioned in the other beam and the source signal obtained from the difference between these two spectra. Such a spectrum pair was obtained in about 6 min and 3 spectrum pairs were obtained of Jupiter on each of the two nights. A fuller description of the spectrometer is being prepared for publication.

Correction of the source signal for atmospheric transmission makes use of the measured sky emission spectrum from an adjacent region of sky (our unpublished work). This method gives good correction for telluric absorption due to H_2O and CO_2 , but not for the severe absorption due to O_3 , which we removed by the usual, though not very reliable, procedure of comparing with a Moon spectrum taken on the same night (Fig. 1). The sky emission spectrum also provides the wavelength calibration from the known positions of the H_2O , O_3 and CO_2 features.

The magnitude of the signals obtained on each of the two nights (8/9 and 9/10 May 1972) were not significantly different and no relative normalization was applied. The intensity calibration was carried out by reference to a spectrum of a region of the lunar surface. This spectrum, after treatment for telluric absorption in the same way as Jupiter, is shown in Fig. 1 and fits a grey body spectrum of temperature 300 K (close to that expected) apart from the ozone absorption and a feature shortwards of $8.5\text{ }\mu\text{m}$ seen also by Murcray⁴. Taking the emissivity of the Moon as 90% (ref. 4), we believe the resultant absolute calibration of the Jupiter spectrum to be good to better than 10%.

The surface brightness spectrum of the central part of the Jovian disk is shown in Fig. 2c and the brightness temperature spectrum in Fig. 2b. An ammonia transmission spectrum⁵ is shown on the same scale for comparison (Fig. 2a).

All the features of the spectrum from 9 to 12 μm can be matched with the details of the ν_2 band of NH_3 . Absorption

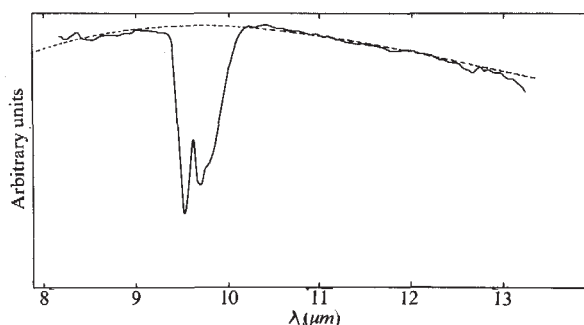


Fig. 1 Lunar spectrum corrected for atmospheric absorption excepting ozone. The dotted line shows a Planck function for $T=300\text{ K}$.

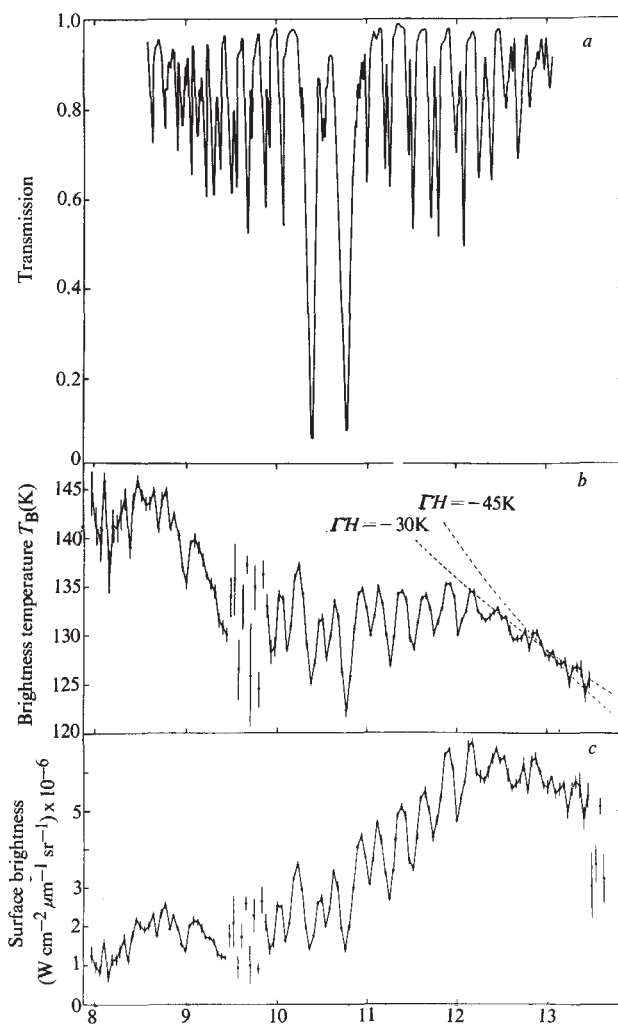


Fig. 2 *a*, Room temperature absorption spectrum of ammonia, $p=0.06\text{ atm}$, $w=0.6\text{ cm atm}$. *b*, Brightness temperature; *c*, Surface brightness of the central region of Jupiter from 8 to $13.5\text{ }\mu\text{m}$.

in the region 8.3 to $9.3\text{ }\mu\text{m}$ seems to be mainly due to the wings of the ν_2 NH_3 band as some of the band features are visible. Certainly band absorption is clearly seen around $12\text{ }\mu\text{m}$ on the other side of the Q branch, although depressed by H_2 absorption. Unfortunately the region considered due to CH_4 in emission is not adequately covered because of the rather late cut-on of the filter used. We consider the fall in brightness temperature T_B beyond $\sim 12\text{ }\mu\text{m}$ to be due to collision induced absorption in H_2 (ref. 2) and a value can be obtained for the lapse rate in this region $\sim 125\text{ K}$ (refs. 6, 7).

For collision induced absorption

$$T_B(\lambda) - T_B(\lambda_1) = \frac{\Gamma H}{2} \ln \frac{\alpha(\lambda)}{\alpha(\lambda_1)}$$

where $\alpha(\lambda)$ is the absorption coefficient at wavelength λ , Γ is the lapse rate and H the scale height. Taking $\lambda_1=13.0\text{ }\mu\text{m}$ and $T_B(\lambda_1)=128\text{ K}$, $T_B(\lambda)$ is as shown in Fig. 2b. This indicates a value of $\Gamma H = -30\text{ K}$, rather less steep than the adiabatic lapse rate $(\Gamma H)_{ad} = -42\text{ K}$ for a H_2 atmosphere, or -50 K for an He atmosphere².

In the absence of low temperature infrared data on NH_3 the room temperature data of France and Williams⁸ are used to obtain a rough estimate of the amount of NH_3 vapour above various temperature levels in the Jovian atmosphere, making allowance for effects of H_2 absorption by taking the brightness temperature as appropriate to a combined optical depth $\tau_{\text{H}_2} + \tau_{\text{NH}_3} \sim 1$. Assuming that at $13.0\text{ }\mu\text{m}$ H_2 absorption

Table 1 Infrared Spectral Features of Jupiter

	λ μm	T_B K	τ_{H_2}	τ_{NH_3}	W_{NH_3} cm atmos	Saturation vapour pressure NH_3 atmos	Predicted W_{NH_3} for $\Gamma H = -30$ K cm atmos
Q branch minimum	10.7	122	0.230	0.770	0.22	5.4×10^{-7}	0.14
Average level band minimum	11.5	128	0.48	0.52	1.3	2.3×10^{-6}	0.60
Average level band mean	11.5	131	0.58	0.42	2.7	5.0×10^{-6}	1.25

is dominant and τ_{H_2} (128 K, 13.0 μm) = 1, τ_{H_2} (128 K, λ) can be found from H_2 data of Kiss *et al.*⁶, and

$$\tau_{H_2}(T, \lambda) = \tau(128, \lambda) \exp\left(\frac{2(T-128)}{\Gamma H}\right)$$

(since $\tau = \alpha(\lambda)w^2/2H$ and assuming $w \sim e^{-h/H}$, where w is the absorber concentration). The France and Williams data⁸ (which has approximately the same resolution as the present observations) are reduced on the basis $\tau_{NH_3} \sim (wP^{1/2})^{1/2}$ and an effective pressure at the 128 K level $\sim \frac{1}{4}$ atmos. The results are shown in Table 1 for a number of features in the spectrum, and are in reasonable agreement with an atmosphere of saturated NH_3 vapour with a lapse rate $\Gamma H \sim -30$ K. (The agreement can in fact be improved by changing the lapse rate to $\Gamma H \sim -15$ K.)

Although the analysis of the data is seriously restricted by the absence of information on NH_3 absorption at Jovian temperatures and pressures, it seems that both the general shape of the spectrum, in which NH_3 and H_2 are seen in absorption, and the estimates of the amount of NH_3 , are consistent with an atmosphere having a negative lapse rate at least up to the 120 K level. We find no evidence for NH_3 in emission as expected by Encrenaz³.

The spectrum is interpreted in terms only of constituents H_2 and NH_3 with some evidence of CH_4 absorption in the region 8.0–8.3 μm . No other features are seen. A similar treatment to that of Gillet, Low and Stein² will lead to similar upper limits for the presence of minor constituents; however we feel that their limit for SiH_4 is too high and should be reduced by more than an order of magnitude to about 0.05 cm atmos, above the 125 K level.

More recently we have observed Jupiter with higher resolution in a study of limb effects from the Radcliffe Observatory, Pretoria, and we hope to present these results after analysis.

These are probably the first observations made with the Tenerife 60-inch telescope, which had become operational only a few weeks earlier, and we thank all those involved in its speedy design and construction, in particular Professor J. Ring and Mr John Long of Imperial College, London. We also thank Dr Carlos Sanchez of the Universidad de la Laguna for help and Dr P. Polden who helped with the observations. One of us (B. J.) acknowledges the support of an SRC studentship.

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Received August 29, 1972.

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Polarization Charging Effect and Thundercloud Electrification

WE have found, using solid state electrometers capable of measuring individual charges during ice-ice collisions, that polarization charging may be an effective charge generating mechanism in glaciated or partly glaciated clouds¹⁻⁴. The high sensitivity of the electrometers made it possible to measure charges as low as 10^{-6} e.s.u. with millisecond transfer times. It seems that nearly all snow crystals carry a charge of this order or greater, and collisions of these crystals with an ice sphere produces an average charge of about 5×10^{-5} e.s.u. when no potential gradient is present. When a potential gradient of 50 V cm^{-1} is present, however, an average charge of 2×10^{-3} e.s.u. is produced during a single collision. This supports our proposed mechanism.

Comparing theoretical results⁵ with the data, we find that the relationship between the distributions of size and charge are as expected. Also, the results are quantitatively described by the theory of polarization charging below an absolute value of potential gradient of $5,000 \text{ V m}^{-1}$. Above this value of electric field, however, the actual charging was greater than predicted, so that one would expect an even greater importance of polarization charging in ice-ice collisions.

A similar effect may also be present during collisions between water drops³⁻⁵ and large hailstones. Impacts of these precipitation elements generally produce a crown which ejects liquid in the form of jets from its upper rim. These jets, in turn,

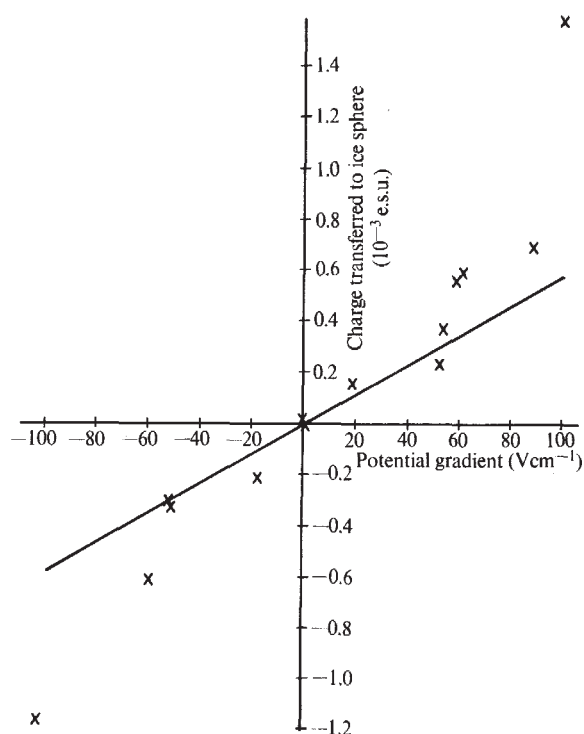


Fig. 1 Effect of electric field on charge transfer during ice-ice interaction. —, Theoretical curve; x, experimental average values.

break up into a large number of small fragments. Without an electric field, small negative charges are separated during disruption which leaves the large hailstone positively charged. The charging depends strongly on the ionic impurities in the water; less charge is separated when impurities are present. Such charge separation is explained by the presence of the double layer at the water-air interface and the electro-kinetic potentials in the liquid.

But in the presence of even moderate fields with positive potential gradients, the sign of the charge separated is reversed and the magnitude of the separated charges is dramatically increased as is shown in Fig. 1. Hence, polarization charging during drop-solid hydrometeor interactions seem entirely analogous to the ice-ice interactions.

We also note that the straight line in Fig. 1 represents the expected charge separation if the drop acted as a rigid, conducting sphere, which bounces during the impact, without disruption. In reality, the drop splatters and this should add to the actual charge separation, due to the electric polarization of the crown and the jets during break-up. In a thundercloud, this particular effect of polarization charging can operate in the lower portions where the temperature is above freezing and solid and relatively large ($r > 300\mu$) liquid hydrometeors co-exist. The effect is as follows. Splashing in the absence of an electric field leave the falling hailstones positively charged and produces a negative potential gradient. The small drop fragments remaining are then carried upward by the updraught, increasing the negative potential gradient so that subsequent splashing results in even larger charge separation. This produces a positive feedback similar to that of the ice-ice interaction, but with the opposite effect: a negative dipole is produced. This enhanced mechanism may be capable of producing the large quantities of positive charge often observed in the lower portions of the cloud.

Our work and the early work of Sartor^{6,7} show that polarization charging is generally effective during the interaction of all particle types, whether hailstones, ice crystals, snow crystals or raindrops. The power of this mechanism is such that the thermoelectric effect, the capture of ions or effects of impurities, are only likely to be effective during the initial stages of cloud electrification. Once, however, a moderate electric field has been built up it is probable that the polarization mechanism dominates.

We¹ have shown that the polarization charging effect alone can produce the electrification as the omnipresent fair weather electric field is sufficient to initiate the field buildup. Of course, as the field builds up to large sizes, negative feedback occurs due to enhanced conduction from electrical discharge effects or the inverse effect, described by Kamra⁸. This is a tendency of the large electric fields to actually suspend the charged particles or droplets, producing, in effect, a termination of further polarization charging.

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The Glenalmond Earthquake Series, February 1970–March 1972

SINCE February 1970, there have been some two dozen small earthquakes in Glenalmond, Perthshire, with epicentres in a very compact source area near the village of Methven. Nearly all of the shocks have been felt in the village, and two of them, on September 7 and November 5, 1971, were more widely felt, and caused some alarm in Perth. The earthquakes listed in Table 1 were recorded by the LOWNET¹ seismic network in Scotland (Fig. 1). Station LA was installed on June 7, 1972, to strengthen the network, and monitor any future activity at Glenalmond.

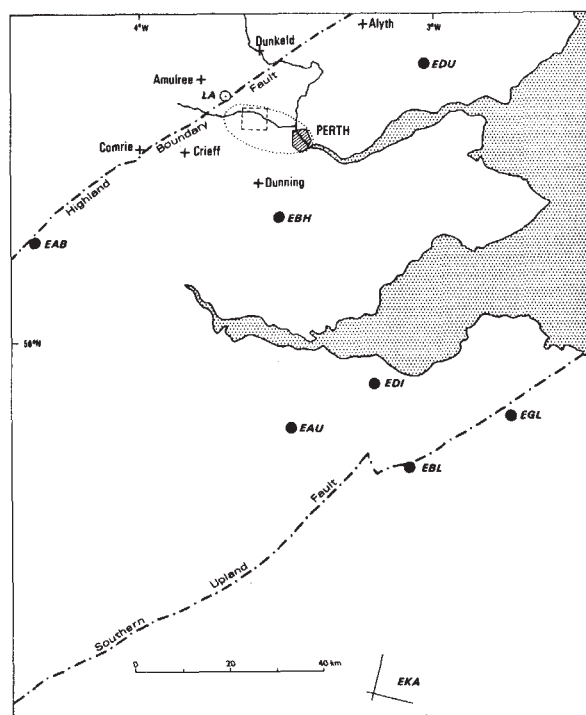


Fig. 1 Map showing the LOWNET sites: LA is a new station operating since June 7, 1972. The dotted line is the MM IV isoseismal for the earthquake on November 5, 1971, and the dashed rectangle outlines the map of Fig. 2.

The parameters listed in Table 1, and plotted in Fig. 2, were calculated by the programme FAMG (S. C. and P. L. Willmore, unpublished). Location is determined by a least squares iterative procedure, measuring travel-times along ray paths in a layered model, which permits variations in the layered structure to be introduced. Depth is determined to the nearest 0.25 km. The Richter Local Magnitude is obtained by the standard methods²; measuring the largest amplitude at each station, and comparing the response with that of a Wood Anderson seismograph. Comparison of the results from the 3-component set in Edinburgh shows a systematic difference between results from the horizontal and vertical components, and results from the vertical seismometers elsewhere in the network have been adjusted to remove this difference. The magnitudes in Table 1 are thus the average of a number of stations.

The structure in the region is now well calibrated, and well recorded events with five or more first arrival P readings can be located accurately. Events with three or four readings can be located with less precision, in particular three readings yield no information about depth. We believe that the absolute positions of 13 of the 15 well recorded events shown in Fig. 2 are a small hypocentral distance (probably less than 1 km) from the true positions; the relative positions are more accurate. The other two well recorded events, 7 and 9, have much larger residuals than the other 13, and their positions may not be so accurate.

We attempted to fit a plane through the group of foci. The least squares fit to the most compact group (excluding events 6, 7, 9 and 18) has a strike almost due north, dipping 35° to the east, with a mean residual of 0.15 km. Including event 6 gave a plane having a strike of 17° east of north, with a dip of 23° , and a mean residual of 0.20 km. Including 7 and 18 in the least squares fit results in planes with mean residuals >0.5 km. There is little to choose between the two planes. Fig. 2 shows vertical sections parallel to the strike and the dip of the plane including event 6.

There is independent evidence that these calculated positions are near the true locations. The compact group of epicentres is close to Methven. All except one of the shocks (event 18), with a magnitude greater than 1.6, have been reported by a particular observer in Methven (who was absent for event 18), and some by other people in the village. The position of the Manse, from which most reports have come, is marked in Fig. 2, where the sections show that it is at a hypocentral distance of between 3 and 4 km from all the events of the series. Independent instrumental data from the UK Atomic Energy Authority array EKA was used to measure the relative depths using the Pg-Pn and Sg-Pg time intervals³. This method is particularly suited to comparing earthquakes with approximately the same epicentre, as in this present series. The

phases from 11 of the larger events were timed by velocity filtering the data from the EKA array on the analogue processor at UKAEA, Blacknest. Fig. 3 shows the relative depths from the Pg-Pn and Sg-Pg time intervals on EKA records, compared with the depths calculated by FAMG from first arrivals on LOWNET. Most of the depths show good correlation. Omitting the two events with largest residuals in the FAMG determinations (events 7 and 9), the line fitted by least squares is

$$DEP_{(EKA)} = (0.86 \pm 0.37) DEP_{(FAMG)} + (3.82 \pm 1.28)$$

The foci seem to lie on a small section of a fault plane. The limitations on the dimensions of the fault plane would be expected to place limitations on the magnitude of any possible earthquake. This is confirmed by a somewhat unusual magnitude/frequency distribution. The statistical population is small, but is complete for events with magnitudes between 1.6 and 2.6. Of these 20 earthquakes, 5 have magnitudes in the largest two classes, which may be the maximum for a source of these particular dimensions.

The source area is 5 km from the Highland Boundary Fault, which at this point has a wide shattered zone, but is thought to be a thrust fault dipping steeply to the NW. The immediate area of the source is covered in glacial drift, except for a line of outcrops along the River Almond, which show several

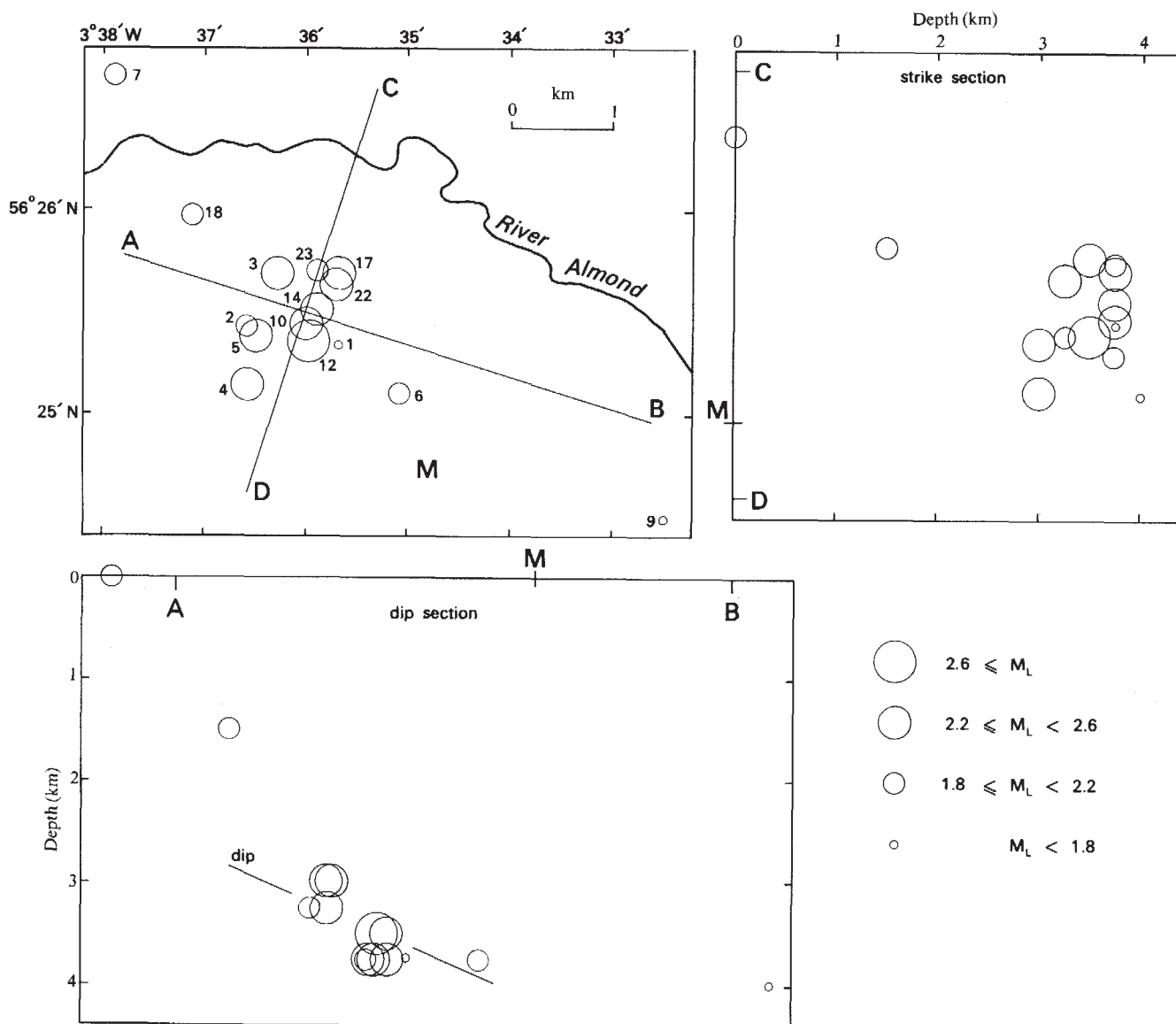


Fig. 2 Map of epicentres, and dip and strike sections through the crust showing the positions of the foci. M marks the position of the Manse, Methven.

faults running SE from the Highland Boundary Fault, including one in the direction of the epicentres. There is also an EW fault of more recent origins (Carboniferous) which probably runs just south of the epicentres. Thus, the foci have little correlation with surface faulting, but the small section of fault plane outlined by the foci would not be expected to be visible at the surface, particularly in an area dissected by many faults.

Seismicity of this region in the past has been dominated by the large number of events in the Comrie area, and a small number of events in other areas. Throughout the region, small earthquakes, occasionally associated with loud noises, have been reported by Davison⁴ and Dollar⁵ from Dunkeld (1816, 1822), Amulree (1819, 1820), Dunning (1809), and felt in Perth (1824, 1855, 1947). An event occurred in 1937 which was widely felt along the Highland Boundary Fault from Comrie to Edzell (Edzell is 35 km NE of Alyth), with maximum intensity at Alyth. In spite of being widely felt, the intensity was nowhere very large (not more than IV MM even at Alyth).

Davison lists more than 400 shocks in the Comrie area between 1788 and 1921, together with many more, which were heard rather than felt. Dollar reports 13 more events in the Comrie/Crieff area between 1921 and 1947, and the British Association for the Advancement of Science reports two further small events in 1958 and 1959; however, in the three years that LOWNET has been in operation, there have been no events detected in the Comrie/Crieff area. The principal events, which were widely felt, occurred in 1789, 1795, 1801, 1839, 1841 and 1844 (the largest, in 1839, would probably have been about magnitude $M_L = 5$). Most of the remainder were felt in one place only, usually Comrie. There have been four main series, each of which has had at least one of the principal events associated with it, and the major series, from 1839 to 1844, included three of the large shocks.

The area of Comrie, Crieff and Glenalmond has given us a more numerous sample of earthquakes in the past 200 yr than anywhere else in Britain. Although most of the Comrie/Crieff events have been as small as those of the present series, about 3% have been felt at considerably greater distances, so

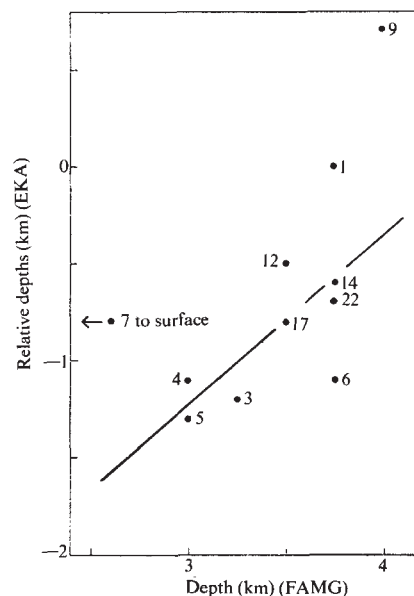


Fig. 3 Comparison of relative depths from Pg-Pn and Sg-Pg times, and depths from FAMG. The line has a slope of 0.86, omitting events 7 and 9.

that the magnitude ceiling of the Glenalmond area, if genuine, does not apply to Comrie/Crieff. We have no information about the extent or alignment of the fault planes of the Comrie/Crieff centre to compare or contrast with that of Glenalmond, but it would be interesting if any future evidence could reveal a difference of scale commensurate with that of the magnitude differences. The comparatively few reports from the Great Glen Fault in the same period show a markedly higher proportion of larger events from this larger and simpler feature.

We thank the many people in Perth and Methven and the surrounding district who have assisted us, in particular Mrs S. Kennedy at the Manse, Methven. We also thank UKAEA,

Table 1 The Glenalmond Earthquake Series

Event No.	Date	Time h min s	Latitude	Longitude	Depth (km)	No. of stations	Mean station residuals (s)	Maximum station residual (s)	Magnitude (M_L)	Standard deviation of magnitude	Whether felt
1	15.02.70	06 13 39.0	56° 25.33'	-3° 35.67'	3.75	5	0.04	0.10	1.6	0.34	F
2	29.10.70	04 40 23.3	56° 25.43'	-3° 36.59'	3.25	7	0.02	0.04	2.0	0.36	F
3	14.04.71	05 25 32.3	56° 25.69'	-3° 36.28'	3.25	6	0.02	0.04	2.5		F
4	15.04.71	12 26 28.1	56° 25.14'	-3° 36.59'	3.00	7	0.07	0.10	2.5	0.30	F
5	15.04.71	12 32 13.4	56° 25.39'	-3° 36.49'	3.00	7	0.04	0.09	2.2	0.19	F
6	17.04.71	08 13 25.5	56° 25.10'	-3° 35.07'	3.75	5	0.03	0.05	2.0		F
7	22.04.71	06 27 36.2	56° 26.35'	-3° 37.97'	0.00	6	0.15	0.36	2.0	0.27	F
8	30.04.71	01 07 19.6	56° 25.40'	-3° 36.50'	2.25	4	0.00	0.00	1.8		F
9	06.08.71	18 38 42.0	56° 24.49'	-3° 32.48'	4.00	5	0.12	0.22	1.6		F
10	08.08.71	01 24 15.3	56° 25.44'	-3° 36.01'	3.75	6	0.03	0.08	2.3	0.35	F
11	31.08.71	23 56 44.0	56° 26.79'	-3° 34.42'	4.25	4	0.01	0.01	1.7		F
12	07.09.71	09 30 35.4	56° 25.36'	-3° 35.97'	3.50	7	0.03	0.12	2.6	0.27	F
13	04.10.71	11 02 14.8	56° 21.80'	-3° 24.36'		3	0.00	0.00			
14	05.11.71	17 09 55.4	56° 25.51'	-3° 35.90'	3.75	6	0.02	0.04	2.5		F
15	06.11.71	06 50 36.4	56° 24.48'	-3° 32.62'	3.25	3	0.00	0.00	0.9		F
16	07.11.71	12 01 31.1	56° 26.23'	-3° 33.89'		3	0.00	0.00	1.9		F
17	07.11.71	12 07 27.0	56° 25.69'	-3° 35.66'	3.50	6	0.04	0.08	2.5	0.36	F
18	10.11.71	10 30 42.4	56° 25.79'	-3° 37.23'	1.50	6	0.06	0.14	2.1	0.29	
19	10.11.71	10 31 24.4	56° 25.10'	-3° 31.48'		3	0.00	0.00	1.0		
20	12.11.71	01 59 12.4	56° 26.77'	-3° 34.94'	5.00	4	0.00	0.00	1.4		
21	16.11.71	19 18 39.6	56° 27.36'	-3° 34.67'	4.00	4	0.01	0.01	1.6		
22	24.11.71	07 55 12.4	56° 25.63'	-3° 35.70'	3.75	7	0.03	0.09	2.2	0.36	F
23	24.11.71	15 48 49.5	56° 25.70'	-3° 35.88'	3.75	7	0.02	0.07	2.0	0.23	F
24	20.02.72	11 38 34.9	56° 20.61'	-3° 22.10'		3	0.00	0.00	0.8		F
25	21.03.72	20 59 53.4	56° 33.05'	-3° 46.51'		3	0.01	0.01	1.6		F
26	31.03.72	01 30 19.6	56° 34.04'	-3° 48.01'		3	0.00	0.00	1.1		F

Note: Depth was determined only where the number of stations recording P arrivals was 4 or greater. Magnitude is the Richter local magnitude for $\Delta \geq 25$ km. A standard deviation is given where there are more than 3 values. In the last column F indicates that the event was felt and noted by an observer in Methven.

Blacknest, for the EKA data and for the use of the analogue processor.

This work has been supported by the Natural Environmental Research Council.

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Received August 23, 1972.

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BIOLOGICAL SCIENCES

On the Supposed "Kenyapithecus africanus" Mandible

ENOUGH is known about *Ramapithecus* species (including "*Kenyapithecus wickeri*") to say that a morphological complex characterizes the earliest hominids. This complex, described in detail elsewhere^{1,2}, includes anteroposterior shortening of the jaw, reduction of canine height, squaring of the molars, lowering of the molar cusps, molarization of the premolars, thickening of cheek tooth enamel, increase in interstitial wear, and increase in the verticality of the incisors and symphyseal region.

As Pilbeam has pointed out⁴, these features should be considered as defining a polythetic set, that is, a set that groups specimens having the greatest number of shared features, with no single feature being either essential to group membership or sufficient to make an organism a member of the group⁵. To be a member of a monothetic set, in contrast, a specimen must possess a definite number of characters, all of which are found in all the members of the set.

Because biological taxa are polythetic sets there are classificatory problems in palaeontology. With respect to the hominid-pongid boundary, most alleged hominids show many of the fore mentioned hominid features. A "*Sugriviapithecus*" mandible, YPM 13811, for example, is as robust at M₃ as any known *Ramapithecus*, but this is not enough to include the specimen as a hominid, because remaining morphological features of the mandible are not hominid-like (elongated molars, high cusps, sectorial P₃, and so on).

A mandible found recently at Kathwanga, Rusinga Island, Kenya (specimen KNM-RU 2087) was described in 1968 by L. S. B. Leakey³ and was called by him No. 394. He considered it to be the oldest hominid and he assigned it to the species "*Kenyapithecus africanus*". This mandible, however, does not have any of the morphological features defining Hominidae, and in every feature which distinguishes apes from hominids the specimen is pongid in character (see Table 1).

(1) Symphyseal region (Characters 1-5 in Table 1). Nothing about the symphyseal region indicates hominid affinities. In hominids, the internal buttressing of the symphysis begins more posteriorly than in pongids, as a result of the shortening of the face and the compaction and reduction of the incisors and canines. The horizontal rami therefore bend towards the midline at or posterior to M₁. KNM-RU 2087, however, has an anterior location of the point at which the horizontal rami begin to bend towards the midline. Furthermore, it has no hominid-like verticality of the incisors or verticality of the long axis of the mandibular symphysis. The rounded chin in

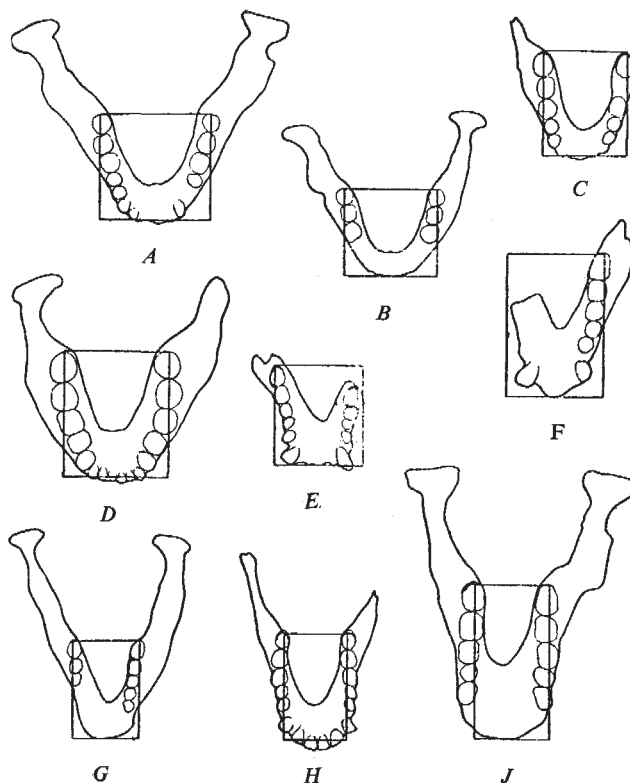


Fig. 1 Leakey's Fig. 3, the "basic rectangles" of some hominoids³. A, *Homo erectus*; B, *Homo sapiens*; C, *Homo habilis*; D, *Australopithecus boisei*; E, *Kenyapithecus africanus*; F, *Proconsul major*; G, *Proconsul nyanzae*; H, *Pan*; J, *Gorilla gorilla*.

KNM-RU 2087 (viewed laterally) is not a feature of special resemblance to hominids and, indeed, Leakey's Fig. 1 includes a cut of a *Gorilla* with a chin as rounded as that of the "*Kenyapithecus africanus*" mandible.

(2) Canine region (Characters 6-10). In the canine region there are, again, no features which suggest hominid ties. Contrary to what Leakey states, the alignment of the buccolingual axis of the canine crown is not more anteroposterior than in *Dryopithecus* (*Proconsul*), and lies within the range of variation for pongids. The difference between hominids and pongids here lies not in the realignment of the canine but rather in the labiolingual compression of the tooth in hominids which results in the principal axis (mesiodistal) being aligned with the tooth row. Even if the lower canine's buccolingual axis in KNM-RU 2087 were more anteroposteriorly aligned it would not make the tooth more hominid-like.

Similarly, bilateral compression of the canine in KNM-RU 2087 is not "associated with a wholly different type of crown structure" from that of *Dryopithecus* and recent pongids³. *Pongo* has just as extreme bilateral compression as this specimen, as do many *Gorilla*. The degree of compression is also within the range of variation of *Dryopithecus* (including *Proconsul*). Second, bilateral compression of the canine is not a hominid feature. In Hominidae, in contrast, the tooth is compressed labiolingually, so that there is a relative expansion of the lateral margins. This is indicated by the low ratio of

$$\frac{\text{Max L}}{\text{Trans B}} \times 100$$

for all known hominids.

The presence of a posterolingual wear facet on the left C is unusual, and is neither a pongid nor hominid character. There possibly was some sort of malocclusion of the dental apparatus, so that the upper canine occluded against the lingual rather than against the buccal aspect of the posterior margin of the lower left canine (or, alternatively, as Leakey has suggested,

Table 1

Character	Typical hominid condition	Specimen KNM-RU 2087	Typical pongid condition
(1) Location of the point at which the horizontal rami begin to bend toward the midline of the mandible	M ₁	P ₃ =Pongid-like	D.: P ₃ Recent: C
(2) Angle of the long axis of the symphyseal region	Recent: Vertical R.: 24–40° from vertical	50° from vertical =Pongid-like	40–50° from vertical
(3) Angle of incisors	Recent: Vertical R.: Probably procumbent	Indeterminate (broken alveolar border)	Recent: Procumbent D.: Probably procumbent
(4) Contour of 'chin', (viewed laterally)	Rounded	Rounded =Nondiagnostic	Recent: Variable D.n., D.s., D.a.: Rounded D.n., D.m.: Usually angular
(5) Size of intercanine breadth	Recent: Small R.: Unknown	†20.5 mm =Nondiagnostic	Recent: Relatively broad D.: Slightly smaller than KNM-RU 2087 per size of mandible
(6) Orientation of the main axis of C	Aligned with tooth row	At an angle of 45° with respect to the tooth row =Pongid-like	At an angle of 45–55° with respect of the tooth row
(7) Degree of bilateral compression of C, $\frac{\text{Max L}}{\text{Trans B}} \times 100$	‡A.: 102.5–111.7 ‡H.s.: 102.9–114.4	†135.2 =Pongid-like	*G.g.: 114–144 *D.n.: 114–128 *D.m.: 121–142 *D.a.: 115–148
(8) Position of mental foramen	Below P ₄	Below P ₄ =Nondiagnostic	§G.g.: Usually below P ₄ §P.t.: Usually below P ₄ §G.g.b.: Usually below P ₃
(9) Height of C relative to the cheek teeth	Small	Large =Pongid-like	Large
(10) Presence of posterolingual wear facet on C	No	Yes =Nondiagnostic	No
(11) Angle of the slope of the anterior face of P ₃ with respect to the level of the tooth row	Recent: 90° R.: 50°	55° =Nondiagnostic	P.t.: 45° G.g.: 50° D.a.: 58°
(12) Presence of sectorial P ₃	Recent: No "K.w.": Yes ‡A.: 117.5	Yes =Nondiagnostic	Yes
(13) Relative elongation of P ₃ , ratio $\frac{\text{Max L}}{\text{Trans B}} \times 100$		†169 =Pongid-like	*G.g.: 144 *D.m.: 171 *D.a.: 157 *D.n.: 155.7 †D.n.: 179 male, 121 female
(14) Relative elongation of P ₄ , ratio $\frac{\text{L}}{\text{B}} \times 100$	‡A.: 84.5	†89.3 =Nondiagnostic	*D.m.: 86.7–5.0 *D.n.: 87.8–96.2 *D.a.: 90.1–120 *G.g.: 86.8 *D.m.: 46–51 *D.s.: 40–44
(15) Robusticity of the mandible at P ₄ , ratio $\frac{\text{P}_4\text{T}}{\text{P}_4\text{D}} \times 100$	*R.: 45.4	†39.7 =Nondiagnostic	
(16) Presence of diastema between C and P ₃	No	No =Nondiagnostic	Usually no
(17) Ratio of mesiodistal length, $\frac{\text{M}_1}{\text{M}_2} \times 100$	*88–98	†78.6 =Pongid-like	*G.g.: 89–96 *D.n.: 78.2 *D.m.: 86.0 *D.f.: 84.5 *D.a.: 85.2
(18) Ratio of mesiodistal length, $\frac{\text{M}_2}{\text{M}_3} \times 100$	*96–104	†89.6 =Pongid-like	*G.g.: 98–107 *D.u.: 87.5 *D.m.: 85.6 *D.f.: 93.0
(19) Relative length of M ₁ , $\frac{\text{L}}{\text{B}} \times 100$	‡A.a.: 109.0 ‡A.r.: 105.8	†112.5 =Nondiagnostic	*G.g.: 116.5 *D.n.: 113†120 *D.m.: 113.3†119 *D.a.: 115.6
(20) Relative length of M ₂ , $\frac{\text{L}}{\text{B}} \times 100$	‡A.: 108.3 *R.: 106.8–122.1	†121.0 =Nondiagnostic	*G.g.: 112.3 *D.n.: 107–121.6 *D.m.: 111.1
(21) Relative length of M ₃ , $\frac{\text{L}}{\text{B}} \times 100$	‡A.a.: 111.0 ‡A.r.: 116.0	†119.5 =Nondiagnostic	*G.g.: 113.5 *D.n.: 112.9–145.7 *D.m.: 126.2 *D.a.: 128.3
(22) Height of the molar cusps	Low	High =Pongid-like	High
(23) Presence of greater anterior than posterior width of M ₃	Recent: Usually no R.: Yes	Yes =Nondiagnostic	Recent: Usually no D.: Yes
(24) Robusticity of the mandible at M ₃ , ratio $\frac{\text{M}_3\text{T}}{\text{M}_3\text{D}} \times 100$	*A.a.: 89.8 *R.: 83.0	53.5 =Pongid-like	*Recent: 65.7–70.5 *D.n.: 57.1–68.0 *D.m.: 62.5–73.9 *D.a.: 53.5–76.5
(25) Angle of posterior divergence of the tooth rows, as measured from P ₄ to M ₃	H.s.: 20° A.: 16–20° R.: 16°	20.5° =Nondiagnostic	Recent: Parallel D.: 17–20°

Data from: * Pilbeam⁴; † Leakey³; ‡ Robinson⁹; § Vogel⁶.Abbreviations: H.s. *Homo sapiens*; A., *Australopithecus*; A.r., *Australopithecus robustus*; A.a., *Australopithecus africanus*; R., *Ramapithecus*; "K.w." *Kenyapithecus wickeri*; P.t., *Pan tryglodytes*; G.g., *Gorilla gorilla*; G.g.b., *Gorilla gorilla beringei*; D., *Dryopithecus*; D.n., *Dryopithecus nyanzae*; D.m., *Dryopithecus major*; D.a., *Dryopithecus africanus*; D.s., *Dryopithecus sivalensis*; D.f., *Dryopithecus fontani*.

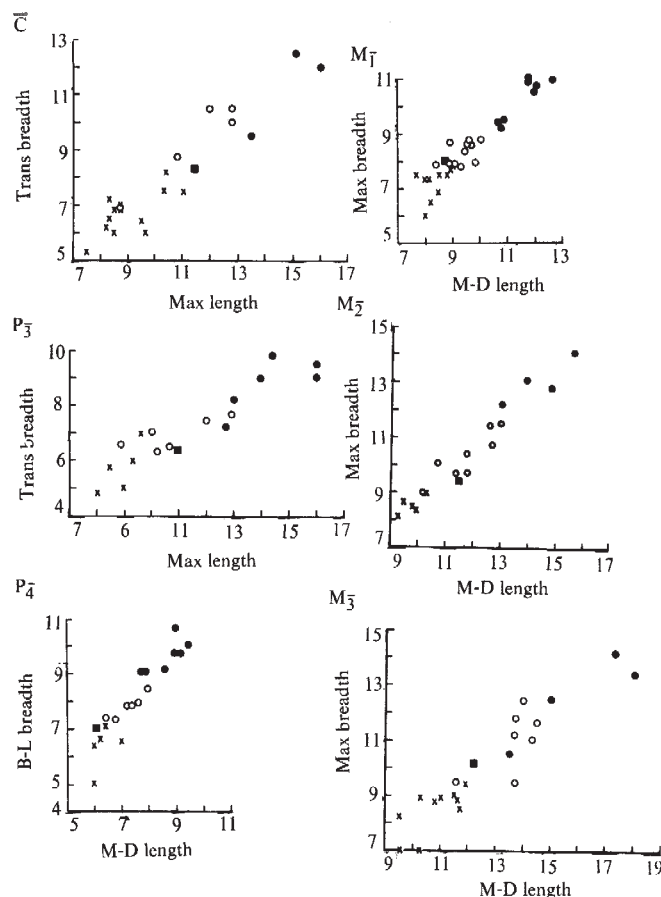


Fig. 2 Bivariate plots of the lower teeth (excluding incisors) or *D. (Proconsul)* and KNM-RU 2087. ●, *D. major*; ○, *D. nyanzae*; ×, *D. africanus*; ■, KNM-RU 2087.

this facet is the result of a piece of the enamel having been broken off).

(3) Premolars (Characters 11–16). The angle of the slope of the anterior face of P_3 is not “wholly unlike the situation in *Proconsul*”, nor is it different from modern pongids. This angle in KNM-RU 2087 is within the range of variation for both *Dryopithecus* and recent apes.

(4) Cheek teeth (Characters 17–25). The small size of M_1 relative to M_2 has been described as a primitive hominoid trait⁴, and it is typically smaller relative to M_2 in *Dryopithecus nyanzae* than in other pongids or hominids. The relative shortness of M_1 in KNM-RU 2087 is closest to that of *D. nyanzae*, and falls much below the low index for known hominids.

The angle of posterior divergence of the tooth rows is not a diagnostic character with respect to the Miocene hominid–ape separation. In the dental arcade of KNM-RU 2087 the significant feature is the anterior location of the point at which the mandible begins to bend toward the midline. And, as already noted, the specimen is pongid-like in this respect.

Leakey attempted to express differences in the arrangement of the teeth by means of what he called “the basic rectangle of the mandible”, which he obtained by drawing one line tangential to the anterior alveolar margins of the two central incisors, another tangential to the two most posterior points of the third molars, and by dropping perpendiculars from the two most posterior points of the third molars to meet the line tangential to the incisors³. Leakey found a vast difference between the “basic rectangles” of recent hominids and recent pongids, and found the basic rectangle of KNM-RU 2087 “to stand very close to the shape seen in *Homo habilis* and *Australopithecus*”, linking it “clearly with the Family Hominidae, rather than the Pongidae”. Kinsey has demonstrated⁷, however, that the “basic rectangle” does not serve to distinguish fossil hominids from fossil apes. The reasons for this become evident when the

factors influencing the shape of the rectangle are examined. These factors are: (1) the degree of divergence of the tooth rows; (2) the location of the bend towards the symphysis; (3) the length of the tooth rows; and (4) the degree of prognathism of the anterior alveolar margin of the central incisors. Although all four factors separate recent hominids from recent pongids, only one—the location of the turn towards the mandibular symphysis—separates Miocene hominids from Miocene apes. And this diminishes the taxonomic significance of the construction for classification of Miocene fossil hominoids.

Furthermore, two significant factors which are taxonomically meaningless contribute to the shape of the “basic rectangle” of KNM-RU 2087. First, the anterior alveolar border of this mandible is broken off, so that the line drawn “tangential to the anterior alveolar margins of the two central incisors” may be misplaced posteriorly. This would make the rectangle appear more hominid-like by shortening the length of the rectangle. Second, examination of the specimen will reveal an apparent distortion of the specimen, a point Leakey fails to bring out. M_2 and M_3 are offset laterally, much more so than in any of the other higher primate mandibles drawn in his Fig. 3 (see Fig. 1). Whereas the vertical sides of all the other rectangles, both pongid and hominid, transect M_1 , in the “*Kenyapithecus africanus*” mandible they are considerably lateral to M_1 . If both this lateral displacement of M_2 and M_3 and the broken anterior alveolar border are corrected for, the “basic rectangle” of KNM-RU 2087 is much more similar to *D. major* and *D. nyanzae* than to any known hominid.

Specimen KNM-RU 2087 is the mandible of an ape, not a hominid, for it has not one of the dental features which defines Hominidae. Wherever there is a separation between hominids and apes, this specimen is pongid-like.

The place to search for the affinities of KNM-RU 2087 is among the other Rusinga ape material, in particular *D. nyanzae*. Its similarity to this pongid is striking—in absolute size the teeth of both are roughly equivalent; the degree of elongation of the molar teeth of KNM-RU 2087 falls within the range of variation of those of *D. nyanzae*; and, as in *D. nyanzae*, the mesiodistal length of M_1 is much less than that of M_2 . All in all, the original description⁸ of *D. nyanzae* fits this specimen well.

I can find only two apparently substantial differences between KNM-RU 2087 and known specimens of *D. nyanzae*: KNM-RU 2087 has a rounded chin, and a greater bilateral compression of the lower canines. The first feature is probably of little significance, because the contour of the “chin” is known to be highly variable within recent pongid species, and there is no reason to assume that this was not so with Miocene apes. In regard to the bilateral compression of the lower canines, the value of the index

$$\frac{\text{Max L}}{\text{Trans B}}$$

for *D. nyanzae* was computed from only four specimens, and it is unlikely that the compression in KNM-RU 2087 would fall outside the range of a larger population size.

Leakey states³ that the intercanine breadth of KNM-RU 2087 is much greater than that of a *D. nyanzae* of comparable size and cites respective measurements of 20.5 mm and 16.5 mm. The “1942 mandible” of *D. nyanzae* (KNM-RU 1674) however, is of a size comparable to KNM-RU 2087 and its intercanine breadth has been estimated at 19 mm by Le Gros Clark and Leakey⁸ and at 19.9 mm by Pilbeam⁴. (KNM-RU 1674 is actually slightly smaller than KNM-RU 2087 in cheek tooth size, decreasing the significance of the relative differences in their intercanine breadths even more.) The intercanine breadth of this specimen does not therefore rule it out as *D. nyanzae*.

In Fig. 2 the measurements of KNM-RU 2087 are plotted with those of *D. (Proconsul)*. With each tooth the specimen falls among the lower values of *D. nyanzae*, and it is clearly closer to *D. nyanzae* than to either of the other species of the

subgenus *Proconsul*. It is therefore my view that specimen KNM-RU 2087 is *Dryopithecus nyanzae*. If the specimens of the species known to date represent a sexually dimorphic population, then this specimen seems to be a male on the basis of its large canine.

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Received February 24; revised June 24, 1971.

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The Bearing of East Rudolf Fossils on Early Hominid Systematics

LEAKEY has provided another very useful progress report on fossil hominid recovery from East Rudolf¹. Some interesting points emerge from this and a previous report²; one is the influence that taxonomic nomenclature can exert on ideas of hominid affinities. His preliminary conclusions suggest that the classification of early hominids based on the South African sample needs revision in the light of the East Rudolf finds^{1,3}. In particular he argues that the East Rudolf specimens provide no support for more than one species of australopithecine. Here I suggest that, on the contrary, his interpretation of the East Rudolf material and mine of the South African finds are in remarkably close agreement; the difference between them is more apparent than real and stems from nomenclatural rather than biological considerations.

Since 1954⁴ it has been believed fairly generally that the sample of early hominids from South Africa represents two lineages; one is robust and less man-like, the other gracile and more man-like. These are usually regarded as specifically distinct (*Australopithecus robustus* and *A. africanus* respectively); in my view⁴⁻⁷ they differed adaptively in ways indicating generic separation (*Paranthropus robustus* and *A. africanus*). Since 1965 (refs. 7, 8, 10) I have advocated placing the latter species in *Homo*.

On Richard Leakey's assessment the known sample of East Rudolf early hominids also contains two similar lineages. The former he places in *Australopithecus*, the latter in *Homo*. The question is whether the two lineages at East Rudolf are basically the same as the two in South Africa.

The robust lineage in both places apparently represents the same sort of hominid with small anterior but large cheek teeth, dished face, low frontal region and, usually, a partial sagittal crest. This is the view of many, including Leakey. Opinions differ on nomenclatural detail, but the basic similarity of the robust forms in the two regions is widely accepted.

The crucial point is whether the more man-like lineages in South Africa and East Rudolf are the same. Viewing the East Rudolf specimens in terms of the diagnostic criteria of the South African gracile hominids demonstrates their similarity. Both have the modest-sized cheek teeth and substantial anterior teeth typical of *H. erectus* and *H. sapiens* but differ from them in having M₂ always larger than M₁ and in having generally suffered less differential reduction of molar size. Although the canines are of the relatively large *Homo* type, the lower canine

in both the East Rudolf and South African groups differ from *H. erectus* and *H. sapiens* in having exaggerated crown asymmetry. This concerns relative height and placing of the apex and the highest point of the cingulum on either side of it, and the tendency to form a strong ridge anterior to the distal lingual groove. In both samples of gracile forms dm₁ has a large but incompletely molarized crown resembling the *H. sapiens* homologue but differing from its usual condition in having clearer expression of cusps and fissure pattern⁹ and in being larger. Judging by KNM-ER-992, the East Rudolf gracile form also agrees with that from South Africa and differs from *H. erectus* and *H. sapiens* with respect to the lingual contour of the mandible in occlusal view; it is V-shaped in the gracile forms but U-shaped in the later hominids.

In all but this latter respect the gracile form from either region sharply differs from the robust form from the same region. Other characters also allow distinction between robust and gracile forms. For example, the ramus is low with wide open sigmoid notch in the gracile form, but high with narrow sigmoid notch in the robust form. In the gracile form the endocoronoid buttress passes directly toward the coronoid tip, but well forward of it in the robust form. Where such distinctions exist between gracile and robust forms in one region, they are of the same sort in the other. The difference between the South African and East Rudolf robust forms are small, as are those between the gracile samples, but the differences between gracile and robust forms in either region are much greater. Gracile hominids from the two regions resemble each other more than either do later hominids such as *H. erectus* and *H. sapiens*. But the gracile and later hominids differ from each other much less than do gracile and robust hominids. On the scale involved when comparing gracile and robust hominids, the diagnostic characters of gracile and later hominids are essentially the same. This is one reason for regarding gracile and later hominids as species of one genus, but distinguishing between them and the robust hominids at the genus level.

Diagnostic characters should be used when comparing robust and gracile hominids. Using inappropriate characters lead to the view that the two forms are not taxonomically distinct. Some gracile mandibles are large and robust. But a large gracile mandible (for example, Sts 7 from Sterkfontein) does not have the small canine and large cheek teeth of the robust form; in this, as well as in form and relative size of ramus, it is typically gracile. A relatively slender mandible of the robust form (as in SK 34 from Swartkrans) has massive cheek teeth and small anterior teeth. It thus properly falls in the robust category despite its comparable size and more slender corpus compared to the gracile Sts 7. Mandibular robustness is notoriously variable in living hominoids and has little taxonomic value. Similarly, although KNM-ER-732 appears gracile compared to other local robust-type skulls, its morphology is not that of gracile skulls: instead it has the low frontal region, brow ridge form, dished face, powerful jugal arch, relatively great postorbital constriction, spheroidal braincase, protuberant and pneumatized mastoid region, and glenoid well above the occlusal plane, that characterize the robust hominids. The absence of the sagittal crest usual in the robust form is not a problem; even in the normally large-crested gorilla smaller females have no crest. Leakey is probably right in interpreting this specimen as a female of the robust form; it does not blur the distinction between robust and gracile hominids.

Because the validity of the dental distinctions of crown size and proportion between gracile and robust forms has been questioned¹¹, it might be argued that these are no more valid taxonomically than mandibular robustness. Attempted refutation of dental proportional differences along the tooth row has been based on tooth-by-tooth comparisons; an inappropriate technique in the circumstances. More appropriate comparisons^{7,12} have demonstrated that proportional differences between gracile and robust hominids are as great as those between the gracile form and the gorilla with respect to

the size relation of the lower canine to the mandibular cheek teeth. But the gracile form and *H. erectus* are closely similar in this respect, and the characteristics of the robust form were stable geographically and through time. Multiple discriminant analysis (to be published by J. T. R. and K. Steudel) of dental data has further confirmed the difference between the gracile and robust forms. A study of postcranial material⁷ indicates that gracile and robust forms differed more than the cranial evidence alone indicates.

The chief points being made are that in morphological, and thus adaptive, terms the robust hominids in the two regions represent the same basic stock; that the gracile hominids in the two regions similarly represent the same stock, and that the two stocks differ considerably. These two stocks seem best differentiated at the genus level for primarily biological reasons, the robust specimens going into *Paranthropus* and the gracile ones into *Homo*⁷⁻⁹. Treatment at the species level within each is a matter of taste. In *Homo* it seems reasonable to have at least two species; *H. africanus* for the South and East African gracile forms, and *H. sapiens* for the rest. Perhaps a third, *H. erectus*, should be added between them. Other workers may prefer more species units; which solution is adopted is relatively unimportant; different solutions relate merely to different ways of discriminating conveniently between members of the same evolutionary stream. Taxonomic problems within one such stream are different from those where two or more are involved⁹.

This separation of the early hominids into two evolutionary streams is what Richard Leakey has done with the East Rudolf specimens. The apparent difference between his approach and that outlined above stems from a comparatively minor point: he evidently used the diagnostic features of the *Paranthropus* stream as a working definition of "australopithecine". He refers, for example, to proportionately very small anterior teeth compared to cheek teeth as characteristic of *Australopithecus* as opposed to *Homo* leading to a statement that only one species of australopithecine occurs at East Rudolf. He thus uses the genus name *Australopithecus* differently from most workers who also include in it the more man-like gracile form which does not have the relatively tiny anterior teeth, or from myself who has never included the robust form in that genus. His use of *Australopithecus* corresponds with my use of *Paranthropus*. So it is not surprising that he wishes to transfer some gracile specimens (for example, the typically gracile Sts 52b) from *Australopithecus* to *Homo*. This is what I did, but believe that all of the South African specimens classified as gracile should be so treated. What Richard Leakey is doing with the East Rudolf specimens is biologically the same as I did with the South African material; the apparent differences stem from nomenclatural rather than biological considerations. His analysis lends no more support to the single species hypothesis of early hominids than does mine.

I thank Drs W. F. C. Blumer, L. Freedman and T. J. Olivier for helpful comments.

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Received August 7; revised September 4, 1972.

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α -Foetoprotein in Rats with Hepatomas Induced by Aflatoxin B₁

THE frequency of hepatocellular carcinoma is higher in parts of tropical Africa than in certain Western countries¹. Elevated levels of serum α -foetoprotein (a foetal globulin) were detected in as many as 80% of the African cases but this was much less frequent in Western patients¹⁻⁷. This difference may be related to the etiology of the disease.

Liver cancer in Africa may be due in part to the ingestion of foods contaminated with aflatoxin B₁ (ref. 8), a potent hepatocarcinogen, and similar mould toxins. However, two different laboratories could not detect α -foetoprotein in sera from animals with liver cancer induced by aflatoxin B₁^{9,10}. We now present preliminary evidence demonstrating that rats fed aflatoxin B₁ and bearing hepatocellular carcinomas do have α -foetoprotein in their sera in amounts related to the dose of the hepatocarcinogen and to the tumour development.

Male Fischer strain rats, 5 weeks old, were placed on a semi-synthetic diet containing 100 p.p.b. (10⁹) of aflatoxin B₁ (isolated from a crude mixture of aflatoxin)^{11,12}. The rats were killed and autopsied, when tumours became apparent by daily palpation after about 20 months, and some were collected. A second group of rats was given aflatoxin B₁, suspended in saline, by gavage at a rate of 25 μ g/day, 5 days each week for 8 weeks (total dose of 1 mg), and then kept on a control diet until they were killed at 12 months. A third group received saline solution at the times group 2 rats were treated. Standard procedures were used in the preparation of tissues for histological examination. The preparation of the monospecific antiserum to α -foetoprotein and the double diffusion immunoprecipitation assay system have been described¹³.

Multicentric hepatocellular carcinomas were seen in all animals of groups 1 and 2, but those in the second group were considerably larger and more extensive. No tumours were noted in the control animals given saline solution.

α -Foetoprotein was detected in the sera of two of six animals from group 1; of four out of four from group 2; and of none of three from group 3 (Table 1). A few rats fed the metabolite aflatoxin B₁, exactly as was done for rats in group 2, showed neither tumours nor detectable levels of serum α -foetoprotein.

Thus, this is the first time α -foetoprotein-positive sera have been demonstrated in animals with hepatocellular carcinomas induced by aflatoxin B₁. Furthermore, the induction of tumours that produce α -foetoprotein seems to be related to the dose of aflatoxin B₁ administered.

We have also demonstrated a precocious and temporary appearance of α -foetoprotein in the serum of rats fed aflatoxin B₁ at the high dose of 4 parts per million¹⁴. At lower doses of 2.0 and 0.2 parts per million this early induction of α -foetoprotein was not observed. Some of the rats given the 2 p.p.m. diet, and tested for about 45 weeks, are beginning to exhibit

Table 1 α -Foetoprotein (AFP) in Sera of Rats treated with Aflatoxin B₁

Group and dose of aflatoxin B ₁ *	Incidence of hepatomas	Presence of AFP (No. rats) (Reaction †)	
(1) 100 p.p.b. in diet	6/6	2	+
		4	-
(2) 25 μ g/day by gavage to total 1 mg	4/4	4	+
(3) Saline control	0/3	3	-

* See text for details of treatment; rats in group (1) were killed after 20 months, in group (2) after 12 months.

† Reaction is positive or negative in the double diffusion method.

hepatomas as well as detectable amounts of α -fetoprotein in their sera.

R. M. K. received a research training fellowship from the International Agency for Research on Cancer, Lyon. J. M. S. received a Damon Runyon Cancer Research Fellowship.

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Risks and Benefits of the Use of Hormonal Pregnancy Test Tablets

In a preliminary communication we suggested¹ the possible teratogenic effect of hormonal pregnancy tests but a recent epidemiological study² failed to confirm the findings. In view of the conflicting results and the practical implications of further use of this test, it seems to be important to give a full account of the unpublished data on which our suggestions were based, and to give a brief summary of other findings.

The observation was made during a research into the possible causes of central nervous system malformations³. We used 100 mothers of spina bifida cases admitted consecutively to two hospitals for surgical treatment during 1965 and 1966. The control mothers had given birth to healthy babies, and because of possible seasonal variations in the incidence of spina bifida, the same number of control cases were collected as the number of index cases admitted each week.

The index and the control mothers were matched as closely as possible according to: age (within the customary five years age group); reproductive history (number of pregnancies, abortions and history of infertility); course of pregnancy (bleeding, hormone treatment, duration and the type of delivery (the latter required for the surgical aspect of the study)), and sex of the baby.

When considering so many criteria it is difficult to match controls exactly. Four very young and seven older index mothers, that is, mothers outside the usual childbearing age, the controls were selected from the nearest age possible, resulting in eleven extra cases in the 20-35 age group (Table 1).

Details were taken of general health and drug intake before and during pregnancy, including minor illness without medical

Table 1 Relevant Conditions Found in Index and Control Patients During the First Trimester of Pregnancy

	Index		Control	
	No test (81 cases)	Test (19 cases)	No test (96 cases)	Test (4 cases)
Maternal age:				
Under 20	5	2	2	1
20-35	66	13	88	2
Over 35	10	4	6	1
Illegitimacy	3	2	6	3
Bleeding	10	3	13	—
Acute infection	22	2	11	—
Chronic infection	1	1	1	—
Contact with infectious diseases	6	2	7	1
Other diseases	5	—	9	—
Miscellaneous drug intake	46	7	45	2
Progesterone treatment	3	—	4	—
Oral pregnancy test	81	19	96	4

care and unprescribed drug intake. Details of the family and reproductive history were also collected. The information was later checked with the subjects' general practitioners through correspondence and a standard questionnaire. Hospitals or other medical authorities to which the patient referred were also contacted in the same manner. The information given by both groups of mothers was reliable. (Details of the method and results are available from the author.)

In this way some possible teratological factors were detected, the most important being the frequent use of 'Primodos' or 'Amenorone Forte' tablets for diagnosis of pregnancy in the index group. The test had been used in 19 index mothers and in only four controls. These tablets contain relatively large doses of synthetic hormones; each tablet of 'Primodos' contains 10 mg of norethisterone acetate and 0.02 mg of ethinyl oestradiol, and 'Amenorone Forte' contains 50 mg of ethisterone and 0.05 mg ethireyloestradiol.

To test the significance of this finding, the index and control groups of mothers were subdivided into those who had the pregnancy test and those who had not. Other possible contributing factors to birth defects were also analysed. No appreciable differences were found between illegitimacy rate, chronic infection and medication during pregnancy in index and control. Differences were found in maternal age and acute infection, but the most significant difference between the two groups was in the use of oral pregnancy test tablets. Analysis of the differences between the groups showed a highly significant result (Table 3). The significance remained when mothers with other predisposing conditions, such as advanced age (over 35 years) or acute infection, were excluded.

Special attention was paid to mothers with poor reproductive history because these cases might be more anxious to confirm their pregnancy, thus increasing the use of pregnancy test tablets. This, however, was not so in our survey (Table 2), but may be

Table 2 Reproductive Pattern of the Index and Control Patients Before the Malformed Baby's Conception

	Index		Control	
	No test (81 cases)	Test (19 cases)	No test (96 cases)	Test (4 cases)
Menarche (after 16 years of age)	10	—	2	1
Infertility of more than 3 years' duration	5	1	3	—
Total number of pregnancies	115	35	116	8
(a) Live births	80	21	88	8
(b) Malformed live and stillbirths	11	4 (2 mothers)	3	—
(c) Abortions	23 (14 mothers)	9 (5 mothers)	23 (19 mothers)	—

Table 3 Use of Oral Pregnancy Test in Index and Control Groups

	No test	Test
Index	81	19
Control	96	4
$\chi^2=9.6$	$P=0.01$ to 0.001	

partly due to matching the reproductive pattern between the groups.

Differences were found in the number of previous malformed babies and in the history of infertility between the two groups. These cases were excluded to eliminate bias from underlying genetic or other factors, and the result remained significant ($P=0.01$ to 0.001). The high level of significance ($P < 0.001$) remains when all mothers with all the above predisposing factors were excluded. These results suggest that the pregnancy test might have contributed to, or acted as a trigger factor in, producing the malformation in one in eight of our cases.

The hormonal pregnancy test is used frequently because it is a simple diagnostic procedure and, according to the manufacturers' (Scherings)⁴ earlier description, it is safe because the hormones do not affect the course of pregnancy. However, Scherings⁵ no longer recommend 'Primodos' for diagnosis of pregnancy themselves.

Because the test is usually carried out in a most vulnerable stage of foetal development, there is a possibility of danger to the embryo. In our experiments the average interval between conception and the test was 5.6 weeks in the survey group and 6.2 weeks in the control group.

The possibility of a teratogenic effect of these tablets has been raised and investigated on several occasions. After Dubowitz⁶ reported on a single case in 1962 Smithells⁷ investigated this problem but his survey did not suggest a harmful effect. In 1967, following the paper by Gal *et al.*, the Royal College of General Practitioners conducted a survey which confirmed the possibility of teratological risks when hormones are administered in early pregnancy^{8,9}. Nelson's comprehensive study showed a similar trend. Some of these findings may be only of borderline statistical significance but the similarity of the trend in these independent surveys is unlikely to occur by chance.

The pregnancy test works by altering the maternal equilibrium and because the hormonal changes produced by the tablets are sufficiently effective to disturb a non-pregnant uterus, there is a strong possibility that the pregnant one can be affected as well. Bleeding frequently occurs in pregnant women following the test. Dienz and Riese⁹ reported bleeding in 4.6% of their cases after the administration of 'Duogyon', and Higgins and Sandler¹⁰ observed it in 10.6% of women receiving 'Primodos'. According to the Medical Letter/Therapeutic Information on Drugs¹², bleeding occurred in 5% of pregnant woman. In our survey bleeding occurred in 13 index cases, 3 of whom had the test.

Probably on this consideration hormonal pregnancy tests are frequently used with the very intention of inducing abortion, apparently successfully in susceptible individuals. The Royal College of General Practitioners' Survey into the Outcome of Pregnancy found a 10% abortion rate after 'Primodos' administration and Brotherton and Craft¹² reported an incidence of 7.6% spontaneous abortion following the use of hormonal pregnancy tests.

It is possible that in less sensitive cases the relatively large dose of hormone in the pregnancy test tablets may interfere with the foeto-placental unit, by upsetting the hormonal balance of the mother, the foetus, or the interaction between them. This may not interrupt pregnancy, but may affect foetal development.

These results indicate the need of fundamental biological studies into the possible harmful effects of hormonal preparation in early pregnancy. Nevertheless, a rigorous statistical analysis has been performed on our data to satisfy those research workers whose assessment of the possible teratogenic

effect of an agent is based more on statistical than clinical considerations. Unnecessary risks are being taken by diagnosing pregnancy with an *in vivo* method when many other reliable *in vitro* methods are available.

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Received November 9, 1971; revised July 27, 1972.

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Reply to Gal

GAL claims to have implicated hormonal pregnancy test tablets as one of the causes of neural tube malformations. These contain high doses of oestrogens and tend to be administered when one would expect the embryo to be most susceptible. Although on immediate inspection of her evidence, 19 tests in pregnancies ending in central nervous system malformations, with only 4 tests in matched controls, might be reason for casting suspicion on these hormone tests, a note of caution should be sounded. First, the choice of controls was unfortunate for while index cases were drawn from a wide area of Southern England, matched controls were chosen from women attending one hospital only. The difference found could be due entirely to local differences in prescribing practices. Indeed, that the controls were perhaps inappropriate in other respects too is suggested by another study by Gal and her co-workers¹ when in an investigation into the possible role of Vitamin A deficiency in the genesis of central nervous system malformation, a significant relationship was demonstrated when the self-same controls were used, which all but disappeared when controls were selected from the individual hospitals where the malformed child was born. Second, it is well known in epidemiological studies that when a number of different factors are related to a medical event that one or more may be related at say a 1 in 100 level of significance. The suggested relationship should, however, always be re-examined by a second run before it is accepted. Both these objections are underlined by a study of the hormone tests in South Wales by Laurence and his co-workers (ref. 2 and personal communication) where on the one hand it was noted that practitioners in one area but not in another frequently used the test, and on the other hand, that no significant difference between the test frequency in index and control pregnancies was found, and were thus unable to confirm Gal's findings. In any case, epidemiological data during the last 30 years would not be in accordance with such an aetiology for the neural tube abnormalities.

It is therefore unlikely that either the hormone pregnancy test or Vitamin A deficiency play a significant part in the genesis of central nervous system malformations.

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BOOK REVIEWS

Plea for Reason

Living on the Third Planet. By Hannes Alfvén and Kerstin Alfvén. Translated by Eric Johnson. Pp. viii+187. (W. H. Freeman and Company: San Francisco and Reading, 1972.) \$29.

HANNES ALFVÉN, the creator of magnetohydrodynamics, Nobel Laureate in Physics, 1970, and Kerstin Alfvén are telling in this little book, in the simplest possible language, the story of life on the Earth, from the amoeba to the politician, from the time when the first lung fish ventured on dry land to the population explosion. Not surprisingly, they do not consider the politician the highest form of life on the Earth. They list many excuses for his shortcomings, but they do not mince words about him:

"In times of war they are anxious that the war should not be so 'uncivilized' that it becomes disagreeable to them personally. They would prefer to sit and fiddle while Rome burns."

The Alfvéns end the chapter on the politicians with some sharp words:

"The most pressing need, surely, is to discover which organizational structures can most effectively promote human coexistence in the cybernetic epoch. It seems likely that a totally new structure is needed."

"It is as remarkable as it is depressing that apparently no competent group of people is seriously at work on this problem, a problem on which the fate of the world depends. Most people seem to feel that human destiny is in the hands of the politicians, and that only the politicians can bear the responsibility."

"But if the politicians prove to be incapable of solving our immense global problem, what then will happen?"

"The answer is that eventually another world war will explode."

These pessimistic remarks are backed up by the next chapter on "Man's Increasing Ignorance", on the growing lag between the ever increasing complication of the global system and our understanding of it. Perhaps some of the young people, for whom this book is chiefly intended, will take it to heart and start learning Russian and Chinese.

The scientists, to whom the next chapter is devoted, may represent a

higher form of life than the politicians, but they too receive some well deserved strictures:

"During the Middle Ages philosophy was called *ancilla fidei*, the 'servant of faith'. Today, science is the loyal and usually silent servant of power."

The Alfvéns do not, however, condemn such expensive pranks as the Moon flights, perhaps because Hannes Alfvén is well known as an inspired cosmic speculator and may have a soft spot for space. Disregarding the consensus of most contemporary physicists, they do not consider it impossible that man may in the end emigrate to some other inhabitable planet, they only qualify it with a "perhaps".

The last chapter but one, "The Symbiosis Between Man and Technology", is a moderate expression of ecological pessimism. Ecological systems do not necessarily possess built-in stability. As a lake can die ("autonomously", without human interference), the whole globe might die, unless reason prevails. But how to instil reason into politicians and the military?

"Before any work of great value can be established, there must first be established international groups from all disciplines who are free to cooperate across national borders without pressure from politicians. Should these groups formulate any concrete proposals, the most difficult goal would still remain: namely to put them into practice."

"It is a long and laborious path. But it is the only possible route, and it is essential that we take the first step soon."

It is a weakness of this book that it appeared in Swedish in 1969, so it was presumably written in 1968, but it has not been brought up to date in the English translation. So much has happened in these last four years that a great part of what the Alfvéns say now appears commonplace. Hannes Alfvén was prominent in Pugwash at the time when the book was written; one must conclude that he did not consider Pugwash even as a first step. One wonders whether he would now consider the giant Stockholm Conference of the United Nations, in which he participated, at least as a beginning? At any rate, the ecological conscience of the

world has been powerfully awakened in the last four years, and this may well be a first step. The book was written before the appearance of Forrester's *World Dynamics*, and it would have been interesting to know what the authors think of this first, still very controversial but undoubtedly powerful quantitative approach to the global problem.

I hope that this little book will have such good sales that a postscript can be added soon in the second printing.

DENNIS GABOR

Algebra for Computation

Linear Algebra. By J. H. Wilkinson and C. Reinsch. (Handbook for Automatic Computation.) Vol. 2. Pp. x+439. (Springer-Verlag: Berlin and New York, 1971.) 72DM; \$20.80.

VOLUMES 1a and 1b describe a particular version of ALGOL and its computer implementation. Successive volumes will present basic algorithms in various computational fields. Volume 2, on numerical linear algebra, divides naturally into Part 1, "Linear Systems, Least Squares and Linear Programming," and Part 2, "Algebraic Eigenvalue Problems." Each part has an introduction describing the procedures, followed by contributions with named authors. Contributed chapters have identical patterns — theoretical background, applicability of algorithms, formal parameter list, ALGOL programs, organizational details, numerical properties, and test results and examples.

In Part 1, eleven contributors consider direct methods for systems of linear equations with general (real and complex) and special matrices (symmetric, positive definite, band type), iterative refinement of solutions, conjugate gradients, Householder transformations for least-squares solutions, weighted row elimination, singular value decomposition, and the simplex method with triangular decomposition.

Part 2 includes Jacobi, Householder, QL and simultaneous iteration for dense symmetric matrices, various QR

methods for symmetric and unsymmetric (real and complex) matrices, an economic Givens-type method for symmetric band matrices, similarity reduction to Hessenberg form, inverse iteration, norm-reducing Jacobi-type (real and complex) methods, the symmetric $Ax = \lambda Bx$ problem, and something on *a priori* matrix "balancing".

Iterative methods for linear systems are excluded because they arise mainly in connexion with other special problems, and the QZ algorithm for the generalized $Ax = \lambda Bx$ problem has been developed too late for inclusion. Otherwise the selection deliberately includes the "best" from the point of view of applicability, economy and accuracy, and it would be hard to see how the space could better be used.

The book is invaluable for computing services and for the practitioner who wants a guaranteed program for a particular purpose. But it also contains a wealth of information about the "how", "why" and "what" of numerical linear algebra, and represents a fine start to this very important series. L. Fox

Language No Barrier

Chemistry Through the Language Barrier: How to Scan Chemical Articles in Foreign Languages with Emphasis on Russian and Japanese. By Emmet Reid. Pp. ix+138. (Johns Hopkins: Baltimore, May 1970.) £2.

THIS remarkable paperback has been written by a veteran chemist who is Professor Emeritus of Chemistry at the

Johns Hopkins University and lays no claim to linguistic proficiency. Indeed, his approach to the rather complex and not inconsiderable problem of the language barrier is summed up in his own words: "I am no linguist; German and French are the only languages I studied; in other languages I just picked up the information". His solution is to use his expert subject knowledge to steer him through a foreign language paper, or as he puts it: "If you want to read Czech, study your chemistry!"

To a linguist some of these statements and the very philosophy must seem strange and somewhat unprofessional since the perhaps insignificant looking words such as "not" or "but" or "however"—or rather their foreign language equivalents—may be easily overlooked in between the chemical terms. But of course the book is not so much concerned with translation as with scanning, that is to determine whether a foreign language original requires subsequent proper and professional translation or not. In this manner the author deals with a whole range of languages such as Italian, French, Dutch, Swedish, Danish, Norwegian, German, Hungarian, Finnish, Czech, Spanish, Romanian, Polish, Russian and Japanese. The author's method of dealing with the Cyrillic alphabet and the Japanese scripts (both Katakana and Hirakana) is ingenious though not very convincing since it relies largely on prior transcription into the Latin alphabet.

Perhaps the real value of this work lies, firstly, in the ease with which the argument is promoted that foreign languages are not really so very difficult to master, and, secondly, in the numerous glossaries and vocabularies

which make up more than half of the slim volume. FELIX LIEBESNY

Effect of Lasers

Effects of High Power Laser Radiation. By John F. Ready. Pp. xii+433. (Academic: New York and London, October 1971.) \$17.50; £8.15.

DR READY, who was one of the very first investigators of the effects of laser radiation on solid targets, has written a most useful book which surveys a wide range of the effects due to intense light and describes many practical applications. The non-linear effects observed with very high power lasers are excluded from consideration. Introductory chapters on the properties of lasers and how to measure their output parameters are followed by descriptions of many of the effects of intense light. There are chapters on heating, ionization, plasma production, gas breakdown, damage in transparent materials and effects on biological systems, which give details of many experiments and discuss the results in the light of theoretical models. Finally, there is a very useful chapter on applications of these effects, which contains much practical information of particular value to engineers involved with machining and metalworking. Copious references and many illustrations are provided, with a fairly adequate subject index. The book is generally well produced, though pages 395–402 were absent in the review copy. The subject is developing rapidly, and I am sure Dr Ready will soon be asked for a second edition. T. P. HUGHES

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